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OPERATION TUMBLER-SNAPPER 1952

United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

Prepared by the Defense Nuclear Agency as Executive Agency
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AFSWP	Exercise Desert Rock IV

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report describes the activities of an estimated 10,600 DOD personnel, both military and civilian, in Operation TUMBLER-SNAPPER, the third nuclear weapons testing series conducted at the Nevada Proving Ground. TUMBLER-SNAPPER consisted of eight nuclear tests conducted from 1 April to 5 June 1952. Activities engaging DOD personnel included Exercise Desert Rock IV programs, scientific experiments, and DOD support activities. Radiological safety criteria and procedures were established and implemented during Operation TUMBLER-SNAPPER to minimize participants' exposure to radioactivity.

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20. ABSTRACT (Continued)

The Defense Nuclear Agency Action Officer, Lt. Col. H. L. Reese, USAF, under whom this work was done, wishes to acknowledge the research and editing contributions of numerous reviewers in the military services and other organizations, in addition to those writers listed in block 7.

Fact Sheet

Defense Nuclear Agency
Public Affairs Office
Washington, D C 20305

Subject: Operation TUMBLER-SNAPPER

Operation TUMBLER-SNAPPER, a series of atmospheric nuclear weapons tests, was conducted by the Atomic Energy Commission (AEC) at the Nevada Proving Ground (NPG) from 1 April to 5 June 1952. The operation consisted of eight nuclear detonations in two phases. The TUMBLER phase, of primary concern to the Department of Defense (DOD), consisted of four weapons effects tests, Shots ABLE, BAKER, CHARLIE, and DOG. These airdropped devices were detonated to collect information on the effect of the height of burst on overpressure. Shots CHARLIE and DOG were also part of the SNAPPER phase, of primary concern to the AEC and the Los Alamos Scientific Laboratory. The other weapons development tests in the SNAPPER phase were Shots EASY, FOX, GEORGE, and HOW. The primary purpose of these four tower shots was to gather information on nuclear phenomena to improve the design of nuclear weapons.

Department of Defense Involvement

About 7,350 of the estimated 10,600 DOD participants in Operation TUMBLER-SNAPPER took part in Exercise Desert Rock IV. The remaining DOD personnel assisted in scientific experiments, air support activities, or administration and support activities at the NPG.

Exercise Desert Rock IV, an Army training program involving personnel from the armed services, included observer programs and tactical maneuvers. Observer programs, conducted at Shots CHARLIE, DOG, FOX, and GEORGE, generally involved briefings on the effects of nuclear weapons, observation of a nuclear detonation, and a subsequent tour of a display of military equipment exposed to the detonation. Tactical maneuvers, conducted after Shots CHARLIE, DOG, and GEORGE, were designed both to train troops and to test military tactics. Psychological tests were conducted at Shots CHARLIE, FOX, and GEORGE to determine the troops' reactions to witnessing a nuclear detonation.

Soldiers from various Sixth Army units provided support for the Exercise Desert Rock IV programs. They maintained and operated Camp Desert Rock, a Sixth Army installation located three kilometers south of the NPG. These soldiers provided essential services such as food, housing, transportation, communications, construction, and security. Some of the Desert Rock support troops worked in the forward areas of the NPG to construct

observer trenches, lay communication lines, provide transportation, and assist with other preparations for Desert Rock IV activities. Many of the Camp Desert Rock support personnel observed at least one detonation during Operation TUMBLER-SNAPPER, and some were called upon to perform support or staff duties in the test areas during nuclear detonations.

DOD personnel also participated in scientific experiments conducted by two test groups at Operation TUMBLER-SNAPPER: the Military Effects Test Group and the Weapons Development Test Group. The Military Effects Test Group was sponsored by Test Command, Armed Forces Special Weapons Project (AFSWP), and involved more DOD participants than did the AEC Weapons Development Test Group. The Los Alamos Scientific Laboratory conducted most of the Weapons Development Test Group activities, but DOD personnel were sometimes involved. Test group participants placed instruments and equipment around ground zero in the days and weeks before the scheduled nuclear test. At shot-time, these personnel were generally positioned at designated observer locations or were working at substantial distances from ground zero. After each detonation, when it was determined that the area was radiologically safe for limited access, these participants returned to the test area to recover equipment and gather data.

DOD personnel also provided air support to Operation TUMBLER-SNAPPER. The Air Force Special Weapons Center (AFSWC), from Kirtland Air Force Base, had primary responsibility for cloud sampling, courier missions, cloud tracking, aerial surveys of the terrain, and other air support as requested. AFSWC consisted of units of the 4925th Test Group and 4901st Support Wing, which staged out of Indian Springs Air Force Base.

Although the AEC Test Manager was responsible for planning, coordinating, and executing Operation TUMBLER-SNAPPER programs and activities, DOD personnel assisted in these duties. They were responsible for overseeing the DOD technical and military operations at the tests.

Summaries of TUMBLER-SNAPPER Nuclear Events

The eight TUMBLER-SNAPPER events are summarized in the accompanying table. The accompanying map shows the ground zeros of these shots.

Shot ABLE, an airdropped nuclear device, was detonated at 0900 hours on 1 April 1952, 793 feet over Area 5 of Frenchman Flat. ABLE had a yield of one kiloton. The event was a weapons effects test and involved DOD personnel from the Military Effects Test Group and the Weapons Development Test Group in about 30 scientific and diagnostic experiments. AFSWC activities included the airdrop, cloud sampling, courier service, cloud tracking, and aerial surveys. In addition, over 150 personnel from the

Strategic Air Command observed the detonation from B-50 aircraft flying over the test area. No formal military training exercises were conducted at this shot, although 15 members of the Camp Desert Rock support staff witnessed the shot. Onsite radiation intensities were characterized by small areas of low-level radioactivity surrounding ground zero. Six hours after the shot, the 0.01 R/h* radiation intensity line was at a radius of about 600 meters from ground zero.

Shot BAKER, an airdropped nuclear device, was detonated at 0930 hours on 15 April 1952, 1,109 feet over Area 7 of Yucca Flat. The BAKER device had a yield of one kiloton. BAKER was also a weapons effects test and involved DOD personnel from the test groups in 45 experiments. AFSWC activities included the airdrop, cloud sampling, courier service, cloud tracking, and aerial surveys. About 170 Strategic Air Command observers flying in B-50 aircraft witnessed the detonation. No formal military training exercises were conducted, but ten members of the Camp Desert Rock staff did witness the shot. Onsite radioactivity was characterized by small areas of radiation around ground zero. About one hour after the shot, the initial radiological survey team found a radiation intensity of 1.2 R/h at ground zero, decreasing to 0.01 R/h 750 meters south of ground zero.

Shot CHARLIE, an airdropped nuclear device, was detonated with a yield of 31 kilotons at 0930 hours on 22 April 1952 about 3,500 feet over Area 7 of Yucca Flat. About one hour after the shot, the initial survey showed that radiation intensities of 0.01 R/h or more were confined within 1,000 meters of ground zero.

As part of Exercise Desert Rock IV, the armed services fielded a troop observer program with 535 participants and a tactical troop maneuver with about 1,675 participants. The tactical maneuver at Shot CHARLIE was conducted by the following units:

Army

- 2nd Battalion, 504th Airborne Infantry Regiment, 82nd Airborne Division, Fort Bragg, North Carolina
- Company B, 167th Infantry Regiment, 31st Infantry Division, Camp Atterbury, Indiana
- Company C, 135th Infantry Regiment, 47th Infantry Division, Fort Rucker, Alabama

*Roentgens per hour

- Tank Platoon, 11th Armored Cavalry Regiment, Camp Carson, Colorado
- Engineer Platoon, 369th Engineer Amphibious Support Regiment, Fort Worden, Washington
- Medical Detachment (augmented), Sixth Army, numerous Sixth Army posts.

Air Force

- 140th Fighter-Bomber Group (Provisional)
  - 140th Fighter-Bomber Wing, Clovis Air Force Base, New Mexico

The CHARLIE tactical maneuver consisted of five activities:

- Observation of the shot
- Psychological testing
- Movement to objective
- Inspection of an equipment display
- Airborne exercise.

After observing the shot from trenches approximately 6,400 meters south of ground zero, the troops were tested by the Human Resources Research Office and the Operations Research Office to determine their reactions to the detonation. The troops then toured the display area and approached as close as 160 meters to ground zero, where they encountered radiation intensities of up to 0.0[illegible] R/h. While ground troops were taking part in these activities, Army paratroopers landed in a drop zone north of ground zero. Some of the paratroopers, however, jumped prematurely and missed the drop zone by as much as 13 kilometers. Five paratroopers were slightly injured on landing. Despite this problem, the exercise was completed as planned.

In addition to Exercise Desert Rock activities, DOD personnel participated in about 50 scientific projects, approximately 190 Strategic Air Command observers witnessed the shot from aircraft flying in the vicinity of the NPG, and AFSWC personnel provided air support, including the bomb drop.

Shot DOG, another airdropped nuclear device, was detonated with a yield of 19 kilotons at 0830 hours on 1 May 1952. Ground zero for DOG, which was detonated more than 1,000 feet above Area 7, was the same as that for Shots BAKER and CHARLIE. The initial radiation survey, taken about one hour after the shot, showed that radiation intensities of 0.01 R/h extended approximately 1,600 meters from ground zero.

The Navy and Marine Corps conducted a troop observer program and a tactical troop maneuver at Shot DOG as part of Exercise Desert Rock IV. The observer program involved approximately 350 Navy and Marine participants. Desert Rock participants observed the shot from trenches 6,400 meters south of ground zero. The tactical maneuver was conducted by about 1,950 Marines from the Marine Corps Provisional Atomic Exercise Unit. This unit consisted of officers and enlisted men from the 1st Provisional Marine Battalion of Camp Pendleton and the 2d Provisional Marine Battalion of Camp Lejeune. The DOG tactical maneuver was the first maneuver conducted by the Marine Corps during continental nuclear weapons testing. As at Shot CHARLIE, troops observed the shot, took psychological tests, and toured display areas. In addition, some participants accompanied AFSWP and Desert Rock monitoring teams on their initial survey of the ground zero area in order to learn radiological monitoring techniques. At Shot DOG, three display areas were established between 270 and 1,600 meters from ground zero. The Marines stopped their tour of the displays at 820 meters from ground zero because of the radiation intensities they encountered.

In addition to Desert Rock activities, DOD personnel participated in about 50 of the scientific experiments conducted by the test groups, about 180 observers from the Strategic Air Command watched the detonation from aircraft flying in the vicinity of the NPG, and AFSWC personnel provided air support, including the bomb drop.

Shot EASY was detonated from a 300-foot tower at 0415 hours on 7 May 1952 in Area 1 of Yucca Flat. The device had a yield of 12 kilotons. DOD participants were involved in approximately 30 of the test group experiments, and AFSWC personnel provided air support. No formal Desert Rock IV training exercises were conducted. However, 1,000 personnel from Camp Desert Rock support units witnessed the shot from the Control Point at Yucca Pass. Onsite residual radioactivity was heaviest around and to the north of ground zero. The initial radiological survey team was unable to complete the survey on shot-day because of the large radiation area and rough terrain. On the day after the shot, the 0.01 R/h line was 900 to 1,000 meters east, south, and west of ground zero but extended about six kilometers north of the shot-tower.

Shot FOX, a 300-foot tower detonation, was fired in Area 4 of Yucca Flat with a yield of 11 kilotons at 0400 hours on 25 May 1952. Most onsite fallout occurred to the northeast of ground zero, overlapping residual radiation from Shot EASY. Ninety minutes after the shot, the 0.01 R/h line extended farther than 6.5 kilometers to the east. High radiation levels to the northeast prevented completion of the initial radiological survey on shot-day. Three days after the shot, the 1.0 R/h line extended less than 500 meters from ground zero, except to the northeast where it reached nearly two kilometers.

During Shot FOX, the largest single activity was the Army troop observer program, part of Exercise Desert Rock IV. Approximately 950 exercise troops from the 701st Armored Infantry Battalion, 1st Armored Division, Fort Hood, Texas, witnessed the shot from trenches 6,400 meters southeast of ground zero. An additional 500 observers from the six continental armies and the service schools also witnessed the shot. The observer program included psychological testing before and after the shot and a tour of the equipment display area.

In addition, DOD personnel were involved in 27 test group experiments. AFSWC personnel provided air support, and about 100 observers from the Strategic Air Command witnessed the shot from aircraft flying in the vicinity of the NPG.

Shot GEORGE, a 300-foot tower detonation, was fired with a yield of 15 kilotons at 0355 hours on 1 June 1952. GEORGE was detonated in Area 3. The initial radiation survey established the 0.01 R/h line at about 1,300 meters to the west, south, and east of ground zero. The area north of the shot-tower could not be surveyed on shot-day because of radiation levels in excess of 10.0 R/h.

The Desert Rock troop observer program and tactical troop maneuver at Shot GEORGE involved approximately 1,800 Army troops. Immediately after they observed the shot from trenches about 6,400 meters south of ground zero, about 500 soldiers toured the equipment display area, located about 500 to 2,500 meters southwest of ground zero. The remaining 1,300 soldiers took part in the tactical troop maneuver, a ground assault on an objective south of ground zero. Immediately after the shot, the troops, accompanied by five tanks, advanced from the trench area toward the objective. When Army monitors preceding the assault detected radiation intensities of 0.5 R/h at about 460 meters from ground zero, the attack was halted. Troops then proceeded to the equipment display areas. The following Army units took part in this maneuver:

- 23rd Transportation Truck Company, Camp Roberts, California
- 31st Transportation Truck Company, Fort Ord, California
- Tank Platoon of the 1st Armored Division, Fort Hood, Texas
- 369th Engineer Amphibious Support Regiment, Fort Worden, Washington.

In addition to these Desert Rock activities, DOD personnel participated in 25 of the test group experiments, AFSWC personnel performed air support missions, and 24 observers from the Strategic Air Command watched the detonation from two B-50s flying in the vicinity of the NPG.

Shot HOW was detonated from a 300-foot tower, located in Area 2 of Yucca Flat, on 5 June 1952 at 0355 hours. Shot HOW, the last weapons test of Operation TUMBLER-SNAPPER, had a yield of 14 kilotons. No Exercise Desert Rock programs were conducted, but DOD personnel did participate in about 30 of the test group projects. The onsite fallout pattern extended to the north and northwest of ground zero, but the initial radiological survey team did not monitor that area because no recovery operations were necessary there. The survey team did measure intensities of 0.01 R/h as far as two kilometers to the west of ground zero.

Safety Standards and Procedures

The Atomic Energy Commission established safety criteria to minimize the exposure of participants to ionizing radiation while allowing them to accomplish their missions. The AEC established a limit of 3.0 roentgens of gamma exposure per 13-week period for Exercise Desert Rock, the joint AEC-DOD organization, and most of AFSWC. AFSWC sampling pilots were authorized to receive up to 3.9 roentgens during the TUMBLER-SNAPPER operation because their mission required them to penetrate the clouds formed by the detonations.

The Test Manager was ultimately responsible for the safety of participants in Exercise Desert Rock IV, of the personnel in the joint AEC-DOD organization, and of individuals residing within 320 kilometers of the NPG. Most onsite and offsite radiological safety procedures were performed by the AFSWP Radiological Safety Group, composed of personnel from the Army, Navy, and Air Force. An officer appointed by Test Command, AFSWP, headed the group.

The Desert Rock Exercise Director was responsible for conducting Exercise Desert Rock IV in compliance with the AEC radiological safety policies. The Desert Rock Radiological Safety Group was usually supervised and assisted by the AFSWP Radiological Safety Group. The AFSWP group was also responsible for processing the film badges worn by Desert Rock participants.

The 4925th Test Group (Atomic) implemented radiological safety procedures for AFSWC personnel at Indian Springs Air Force Base. For AFSWC personnel at Kirtland Air Force Base, the 4901st Support Wing (Atomic) carried out these procedures.

Although the missions and activities of each organization were different, the general radiological safety procedures followed by all groups were similar:

- Orientation and training - preparing radiological monitors for their work and familiarizing participants with radiological safety procedures
- Personnel dosimetry - issuing and developing film badges and evaluating gamma radiation exposures recorded on film badges

- Use of protective equipment - providing clothing, respirators, and other protective equipment
- Monitoring - performing radiological surveys and controlling access to radiation areas
- Briefing - informing observers and project personnel of radiological hazards and the radiological conditions in the test area
- Decontamination - detecting and removing contamination from personnel and equipment.

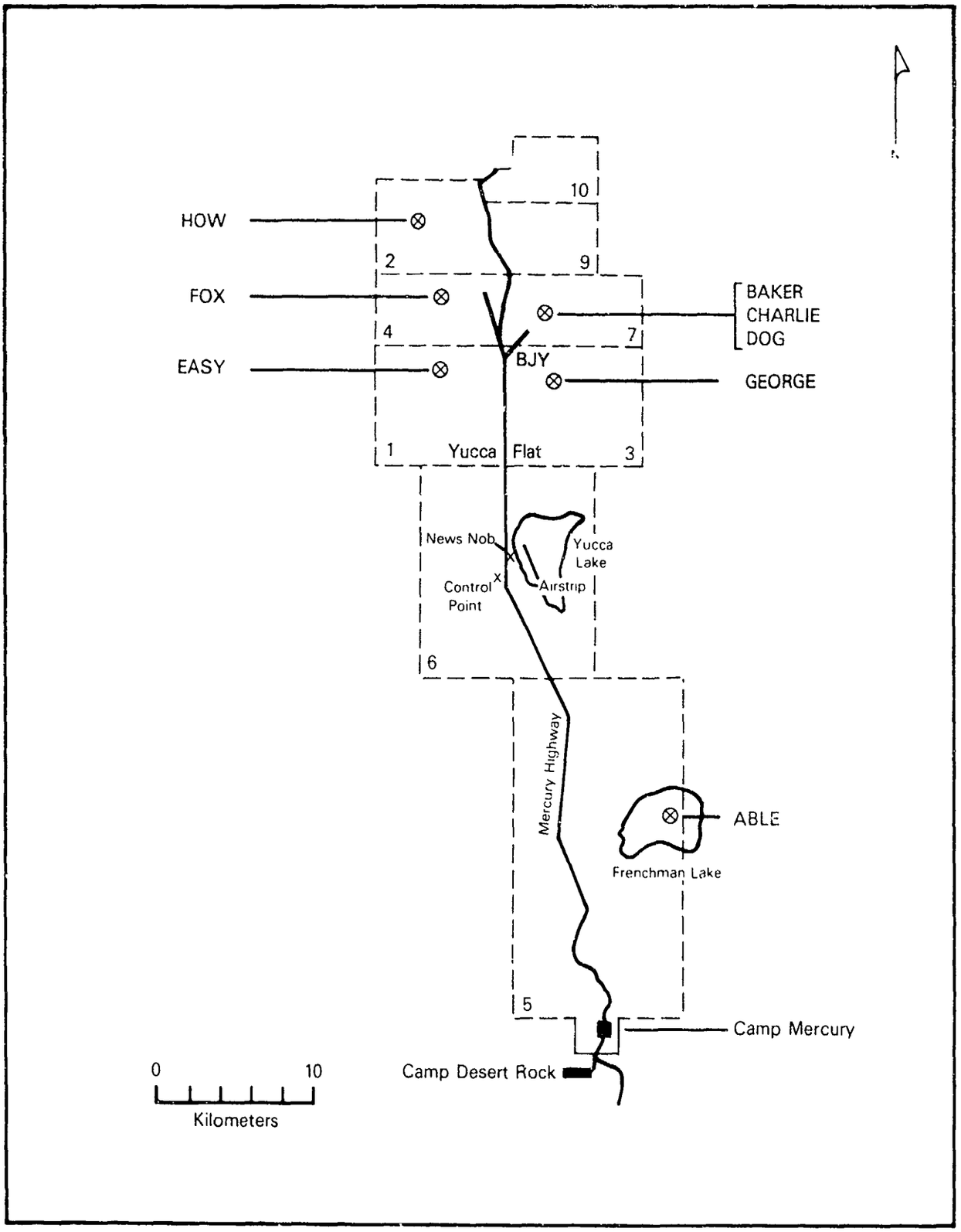
Radiation Exposures at TUMBLER-SNAPPER

As of June 1982, the military services had identified by name 5,064 participants in TUMBLER-SNAPPER. Film badge data are available for 1,803 of these participants, as shown in the "Summary of Dosimetry for Operation TUMBLER-SNAPPER" table. Forty-two DOD participants who were subject to the joint AEC-DOD organization limit of 3.0 roentgens exceeded it, and eight individuals subject to the 3.9 roentgen AFSWC limit received exposures in excess of the stipulated level.

SUMMARY OF OPERATION TUMBLER-SNAPPER EVENTS (1952)

Shot	ABLE	BAKER	CHARLIE	DOG	EASY	FOX	GEORGE	HOW
Sponsor	DOD-LASL	DOD-LASL	DOD-LASL	DOD-LASL	LASL	LASL	LASL	LASL
Planned Date	1 April	15 April	22 April	29 April	6 May	13 May	20 May	27 May
Actual Date	1 April	15 April	22 April	1 May	7 May	25 May	1 June	5 June
Time*	0900	0930	0930	0830	0415	0400	0355	0355
NPG Location	Frenchman Lake (Area 5)	Area 7	Area 7	Area 7	Area 1	Area 4	Area 3	Area 2
Type of Detonation	Airdrop	Airdrop	Airdrop	Airdrop	Tower	Tower	Tower	Tower
Height of Burst (Feet)	793	1,109	3,447	1,040	300	300	300	300
Yield (Kilotons)	1	1	31	19	12	11	15	14

* Pacific Standard Time



GROUND ZEROS FOR OPERATION TUMBLER-SNAPPER AT THE NEVADA PROVING GROUND

SUMMARY OF DOSIMETRY FOR OPERATION TUMBLER-SNAPPER AS OF JUNE 1982

Service	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Gamma Exposure (Roentgens)					Number of Personnel with Zero Gamma Exposure*	Average Gamma Exposure (Roentgens)	Maximum Gamma Exposure (Roentgens)
			<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+			
Army	1786	843	295	463	61	17	7	216	.396	10.8
Navy	493	130	51	51	26	2	0	13	.594	4.2
Marine Corps	1980	25	22	2	1	0	0	21	.070	1.5
Air Force	416	416	177	184	36	17	2	59	.497	7.6
Scientific Personnel, Contractors, and Affiliates	389	389	206	98	72	12	1	118	.575	6.1
TOTAL	5064	1803	751	798	196	48	10	427	.468	

* The number of personnel in this column is also represented in the <.1 Gamma Exposure column.

PREFACE

Between 1945 and 1962, the U.S. Government, through the Manhattan Engineer District and its successor agency, the Atomic Energy Commission (AEC), conducted 235 atmospheric nuclear weapons tests in the United States and in the Atlantic and Pacific Oceans. In all, an estimated 220,000 Department of Defense (DOD) participants, both military and civilian, were present at the tests. Of these, approximately 90,000 were present at the atmospheric nuclear weapons tests conducted at the Nevada Proving Ground (NPG),* northwest of Las Vegas, Nevada.

In 1977, 15 years after the last above-ground nuclear weapons test, the Center for Disease Control+ noted a possible leukemia cluster among a small group of soldiers present at Shot SMOKY, a test at Operation PLUMBBOB, the series of atmospheric nuclear weapons tests conducted in 1957. Since that initial report by the Center for Disease Control, the Veterans Administration has received a number of claims for medical benefits from former military personnel who believe their health may have been affected by their participation in the weapons testing program.

In late 1977, the Department of Defense began a study to provide data to both the Center for Disease Control and the Veterans Administration on potential exposures to ionizing radiation among the military and civilian participants in atmospheric nuclear weapons testing. The DOD organized an effort to:

- Identify DOD personnel who had taken part in the atmospheric nuclear weapons tests

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*Renamed the Nevada Test Site in 1955.

+The Center for Disease Control is part of the U.S. Department of Health and Human Services (formerly the U.S. Department of Health, Education, and Welfare).

- Determine the extent of the participants' exposure to ionizing radiation
- Provide public disclosure of information concerning participation by DOD personnel in the atmospheric nuclear weapons tests.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report on Operation TUMBLER-SNAPPER is based on the military and technical documents associated with these atmospheric nuclear weapons tests. Many of the documents pertaining specifically to DOD involvement in TUMBLER-SNAPPER were found in the Modern Military Branch of the National Archives, the Defense Nuclear Agency Technical Library, and the Office of Air Force History.

In certain cases, the surviving historical documentation of activities conducted during Operation TUMBLER-SNAPPER addresses test specifications and technical information, rather than the personnel data critical to the study undertaken by the Department of Defense. Moreover, these documents sometimes have inconsistencies in vital facts. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader.

In addition to these inconsistencies in information, the documents describing projects of the Armed Forces Special Weapons Project (AFSWP) do not always present project titles and agencies consistently. To make this information as uniform as possible, the reports on TUMBLER-SNAPPER use weapons test report titles for each project. Information concerning the planned and actual dates and yields of the test detonations is taken from the Department of Energy, Announced United States Nuclear Tests, July 1945 through 1979 (NVO-209). Other facts, such as meteorological conditions and dimensions of the clouds formed by the detonations, are taken from DNA 1251-1, Compilation of Local Fallout Data from

Test Detonations 1945-1962, Volume 1, except in instances where more specific information is available elsewhere.

For several of the Exercise Desert Rock and test organization projects discussed in these volumes, the only available documents are the Sixth Army Desert Rock IV operation orders and the Test Director's schedule of events from "Operation Order 1-52." These sources detail the plans developed by DOD and AEC personnel during Operation TUMBLER-SNAPPER; they do not necessarily describe the projects as they were actually conducted. Although some of the after-action documents summarize the projects performed during the TUMBLER-SNAPPER Series, they do not always supply shot-specific information. In the absence of shot-specific after-action reports, projects are described according to the way they were planned. The references indicate whether the description of activities is based on the schedule of events, operation orders, or after-action reports.

ORGANIZATION AND CONTENT OF OPERATION TUMBLER-SNAPPER REPORTS

This volume details participation by DOD personnel in Operation TUMBLER-SNAPPER, the third atmospheric nuclear weapons testing series conducted at the Nevada Proving Ground. Two other publications address DOD activities during Operation TUMBLER-SNAPPER:

- Multi-shot volume: Shots ABLE, BAKER, CHARLIE, and DOG, the First Tests of the TUMBLER-SNAPPER Series
- Multi-shot volume: Shots EASY, FOX, GEORGE, and HOW, the Final Tests of the TUMBLER-SNAPPER Series.

The volumes addressing the test events of Operation TUMBLER-SNAPPER have been designed for use with one another. The series volume provides general information on Operation TUMBLER-SNAPPER that applies to the series as a whole, such as historical background, organizational relationships, and radiological safety

procedures. The two multi-shot volumes combine shot-specific descriptions for the eight TUMBLER-SNAPPER nuclear events. Descriptions of activities concerning any particular shot in Operation TUMBLER-SNAPPER may be supplemented by the general organizational and radiological safety information contained in this volume. In addition, this volume contains a bibliography of works consulted in the preparation of all three Operation TUMBLER-SNAPPER reports, while the multi-shot volumes contain a bibliography only of the sources referenced in each of those texts.

This volume is divided into six chapters. Chapter 1 gives the background of Operation TUMBLER-SNAPPER, including the historical context of the series, the layout of the Nevada Proving Ground, the eight events in the series, and the activities of DOD participants. Chapter 2 describes the joint AEC-DOD organization and Exercise Desert Rock, the two groups with major DOD participation at Operation TUMBLER-SNAPPER. This chapter defines the responsibilities of each group in planning, administering, and supporting the various nuclear test events and in conducting other activities in conjunction with those tests. Chapter 3 discusses the Exercise Desert Rock IV military maneuvers conducted during Operation TUMBLER-SNAPPER, and chapter 4 describes the scientific experiments and support activities engaging DOD personnel and coordinated by the joint AEC-DOD organization. These chapters define the objectives of the activities, describe the planned and actual procedures, and indicate at which shots the programs occurred. Chapter 5 describes the radiological criteria and procedures in effect during Operation TUMBLER-SNAPPER for each of the DOD groups with significant participation. Chapter 6 presents the results of the radiation protection program during Operation TUMBLER-SNAPPER, including an analysis of film badge readings for DOD personnel.

The information in this report is supplemented by the Reference Manual: Background Materials for the CONUS Volumes. It summarizes information on radiation physics, radiation health concepts, exposure criteria, and measurement techniques. It also has a list of acronyms and a glossary of terms used in the DOD reports addressing test events in the continental United States.

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC	Atomic Energy Commission
AFB	Air Force Base
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
BCT	Battalion Combat Team
BJY	BUSTER-JANGLE Y
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Inc.
HumRRO	Human Resources Research Office
IBDA	Indirect Bomb Damage Assessment
LASL	Los Alamos Scientific Laboratory
NPG	Nevada Proving Ground
ORO	Operations Research Office
R/h	Roentgens per hour
SAC	Strategic Air Command
UCLA	University of California at Los Angeles
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Operation TUMBLER-SNAPPER, the series of atmospheric nuclear weapons tests conducted in the continental United States from 1 April to 5 June 1952, consisted of eight nuclear detonations. TUMBLER-SNAPPER involved about 10,600 DOD personnel participating in observer programs, tactical maneuvers, and scientific and diagnostic studies. The series was intended to test nuclear weapons for possible inclusion in the defense arsenal and to improve military tactics, equipment, and training.

The purpose of this volume is to summarize information on organizations, procedures, and activities of DOD personnel in Operation TUMBLER-SNAPPER. This chapter introduces the series with background information on:

- The international and domestic situation that existed in 1952 when the TUMBLER-SNAPPER tests were conducted
- The origin of Operation TUMBLER-SNAPPER
- The Nevada Proving Ground facilities
- The eight individual nuclear events
- DOD participation in this test series.

This information provides a basis for understanding the nature and extent of DOD participation discussed in more detail in this volume and in the TUMBLER-SNAPPER multi-shot reports.

1.1 INTERNATIONAL AND DOMESTIC CONDITIONS INFLUENCING OPERATION TUMBLER-SNAPPER

Operation TUMBLER-SNAPPER was planned and conducted to diversify and thus strengthen the U.S. nuclear arsenal. The

continuing development of nuclear technology was important because the postwar defense policy of the United States rested largely upon its ability to deter attack and general war by threatening a major aggressor with nuclear retaliation. The reliance on nuclear weapons increased in 1949 when the Soviet Union detonated its first nuclear device and the United States lost its monopoly on nuclear firepower. As a new defense policy evolved in the early 1950s, two additional factors challenged the ability of the U.S. Armed Forces to defend American interests and to protect its allies during limited hostilities:

- The commitment of U.S. ground forces to the Korean peninsula
- The inability of the United States' European allies to develop effective military capabilities.

In both cases, the United States experienced difficulties because of limitations in military manpower, which emphasized the need for a U.S. defense policy based not on large standing armies, but on new technological advances, particularly in nuclear weapons.

The Chairman of the Atomic Energy Commission strongly advocated the development of nuclear devices for tactical purposes. Describing prospects for new types of nuclear weapons, the AEC Chairman stated in 1951:

> What we are working toward here is a situation where we will have atomic weapons in almost as complete a variety as conventional ones....This would include artillery shells, guided missiles, torpedoes, rockets and bombs for ground-support aircraft....We could use an atomic bomb today in a tactical way against enemy troops in the field, against military concentrations near battle areas and against other vital military targets without risk to our own troops. We are steadily increasing, through our technological and production progress, the number of situations in which atomic weapons can be effectively employed in battle areas (163).*

*All sources cited in the text are listed alphabetically in the Bibliography at the end of this volume. The number given in the text is the number of the source document in the Bibliography.

While developing nuclear weapons for tactical purposes, government officials attempted to inform the American public about the potential use of nuclear devices to halt aggression without simultaneously destroying large urban centers and populations. Consequently, reporters were present during the first tactical maneuver of Exercise Desert Rock IV, which occurred after the detonation of CHARLIE, the third TUMBLER-SNAPPER shot. Reporters had also witnessed Desert Rock operations in earlier nuclear weapons testing series.

The armed services participated in nuclear testing to determine the military value of weapon effects. The tests indicated that two elements were essential to a defense policy based on nuclear weapons. First, as a deterrent to general war or overt aggression, the Air Force Strategic Air Command had to be armed with effective nuclear weapons. Second, if a limited aggression threatened a U.S. ally and ground intervention was called for, military forces needed to be trained in the tactical use of nuclear weapons. The best way for troops to become familiar with the new weapons was through field exercises (141; 161). The TUMBLER-SNAPPER testing addressed both aspects of defense policy -- effective nuclear weapons and troop training in tactical nuclear warfare.

1.2 ORIGINS OF OPERATION TUMBLER-SNAPPER

TUMBLER-SNAPPER, conducted in the spring of 1952, was planned as two separate weapons testing programs: Operation TUMBLER and Operation SNAPPER. In August 1951, the Armed Forces Special Weapons Project advised the Departments of the Army, Navy, and Air Force that the AEC would probably conduct one or more nuclear weapons tests during the spring of 1952. Although the scope of the contemplated tests had not yet been determined, AFSWP requested that, by 5 October 1951, the military recommend projects for inclusion at the detonations. The Armed Forces

submitted recommendations in October, at which time the AEC formally advised the DOD that it intended to conduct a nuclear weapons testing series at the Nevada Proving Ground beginning on 1 May 1952. The AEC also indicated that most of the shots in the series, which it designated Operation SNAPPER, would be tower detonations (8; 88; 138; 155).

During September and October 1951, AFSWP formulated a military effects test program for Operation SNAPPER, integrating the proposals furnished by the Armed Forces. In early November 1951, AFSWP proposed its military effects program, consisting of about 32 projects, to the Research and Development Board of DOD for approval. The Research and Development Board approved the program, recommending several modifications in the plans. On 19 January 1952, the Joint Chiefs of Staff approved the revised plans for the AFSWP test program (8; 16; 138).

Before DOD gave final approval to Operation SNAPPER, data were obtained from the 1951 Operation BUSTER-JANGLE indicating the need for an additional nuclear weapons testing series. Some of the projects performed at BUSTER-JANGLE revealed significant discrepancies between the predicted and actual overpressure resulting from airbursts. Consequently, on 14 December 1951, AFSWP recommended to the Joint Chiefs of Staff that a series of nuclear tests be conducted, primarily to measure the overpressure caused by airbursts. On 10 January 1952, the Joint Chiefs of Staff approved the recommendation and requested that the AEC assume responsibility for administering the additional nuclear events. First referred to as the "Quickie" Operation, these events were renamed TUMBLER and scheduled to be conducted before 1 May 1952, the beginning date for Operation SNAPPER (8; 138; 148).

Operation TUMBLER, designed by AFSWP, incorporated several of the original SNAPPER experiments devoted to basic thermal and

blast measurements. Because the concerns of the two series sometimes overlapped, they were combined into one operation, TUMBLER-SNAPPER. Although plans for the combined operation were occasionally revised, the test programs had been formulated by February 1952 (8; 88; 138; 148; 155).

According to the plans, Operation TUMBLER-SNAPPER consisted of two parts. The TUMBLER phase, essentially weapons effects tests, was designed to obtain additional information on the effect of the height of burst on the overpressure caused by a nuclear detonation. Shots ABLE and BAKER, fired solely to gain overpressure data, were part of TUMBLER. The SNAPPER phase, basically weapons development events of primary concern to the AEC and the Los Alamos Scientific Laboratory (LASL), tested weapons for inclusion in the defense arsenal and studied techniques to be used during Operation IVY, scheduled for the fall of 1952. Shots EASY, FOX, GEORGE, and HOW, as weapons development tests, were part of SNAPPER. CHARLIE and DOG, involving both weapons effects and weapons development studies, were part of both the TUMBLER and SNAPPER phases (8; 138; 148).

In a 24 January 1952 letter, the Chief of AFSWP presented Air Force Headquarters with a schedule for TUMBLER-SNAPPER. The first four shots were to be airdrops, and the remaining events were to be detonated on 300-foot towers. The first airdrop was scheduled for 1 April 1952. With the exception of the second airdrop, planned for 15 April, the remaining shots were scheduled for consecutive weeks, one shot per week. The AEC later canceled a ninth detonation, a tower shot which had been scheduled for 4 June, because the first eight tests yielded sufficient data (8; 20; 88; 138; 148; 155).

Although the schedule for Operation TUMBLER-SNAPPER was revised several times, the planned and actual test dates

generally corresponded, as indicated in table 1-1.* Schedule changes in the later part of the series resulted primarily from adverse weather conditions (73; 74; 87).

1.3 THE NEVADA PROVING GROUND

Operation TUMBLER-SNAPPER, like Operations RANGER and BUSTER-JANGLE, was conducted at the Nevada Proving Ground. Originally established by the Atomic Energy Commission in December 1950, the NPG, now known as the Nevada Test Site, is located in the southeastern part of Nevada, 100 kilometers+ northwest of Las Vegas, as shown in figure 1-1.

The Nevada Proving Ground, depicted in figure 1-2, is an area of high desert and mountain terrain encompassing approximately 1,600 square kilometers in Nye County. On its eastern, northern, and western boundaries, the NPG adjoins the Las Vegas Bombing and Gunnery Range (later designated the Nellis Air Force Rang), of which it was originally a part. This area has been the location for the atmospheric nuclear weapons tests conducted within the continental United States from 1951 to the present.

The nuclear weapons tests of Operation TUMBLER-SNAPPER were conducted in two distinct geographical areas: Yucca Flat and Frenchman Flat. Yucca Flat is a 320-square-kilometer desert valley surrounded by mountains. Situated in the north-central part of the Nevada Proving Ground, Yucca Flat was the location of

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*Universal Transverse Mercator (UTM) coordinates are used in this report, as seen in table 1-1. The first three digits refer to a point on an east-west axis, and the second three digits refer to a point on a north-south axis. The point so designated is the southwest corner of an area 100 meters square.

+Throughout this report, surface distances are given in metric units. The metric conversion factors include: 1 meter = 3.28 feet; 1 meter = 1.09 yards; and 1 kilometer = 0.62 miles.

Table 1-1: SUMMARY OF OPERATION TUMBLER-SNAPPER EVENTS (1952)

Shot	ABLE	BAKER	CHARLIE	DOG	EASY	FOX	GEORGE	HOW
Sponsor	DOD-LASL	DOD-LASL	DOD-LASL	DOD-LASL	LASL	LASL	LASL	LASL
Planned Date	1 April	15 April	22 April	29 April	6 May	13 May	20 May	27 May
Actual Date	1 April	15 April	22 April	1 May	7 May	25 May	1 June	5 June
Time*	0900	0930	0930	0830	0415	0400	0355	0355
NPG Location	Frenchman Lake (Area 5)	Area 7	Area 7	Area 7	Area 1	Area 4	Area 3	Area 2
UTM Coordinates	945729	872044	871045	871044	798009	795056	871004	784104
Type of Detonation	Airdrop	Airdrop	Airdrop	Airdrop	Tower	Tower	Tower	Tower
Height of Burst (Feet)	793	1,109	3,447	1,040	300	300	300	300
Yield (Kilotons)	1	1	31	19	12	11	15	14

* Pacific Standard Time

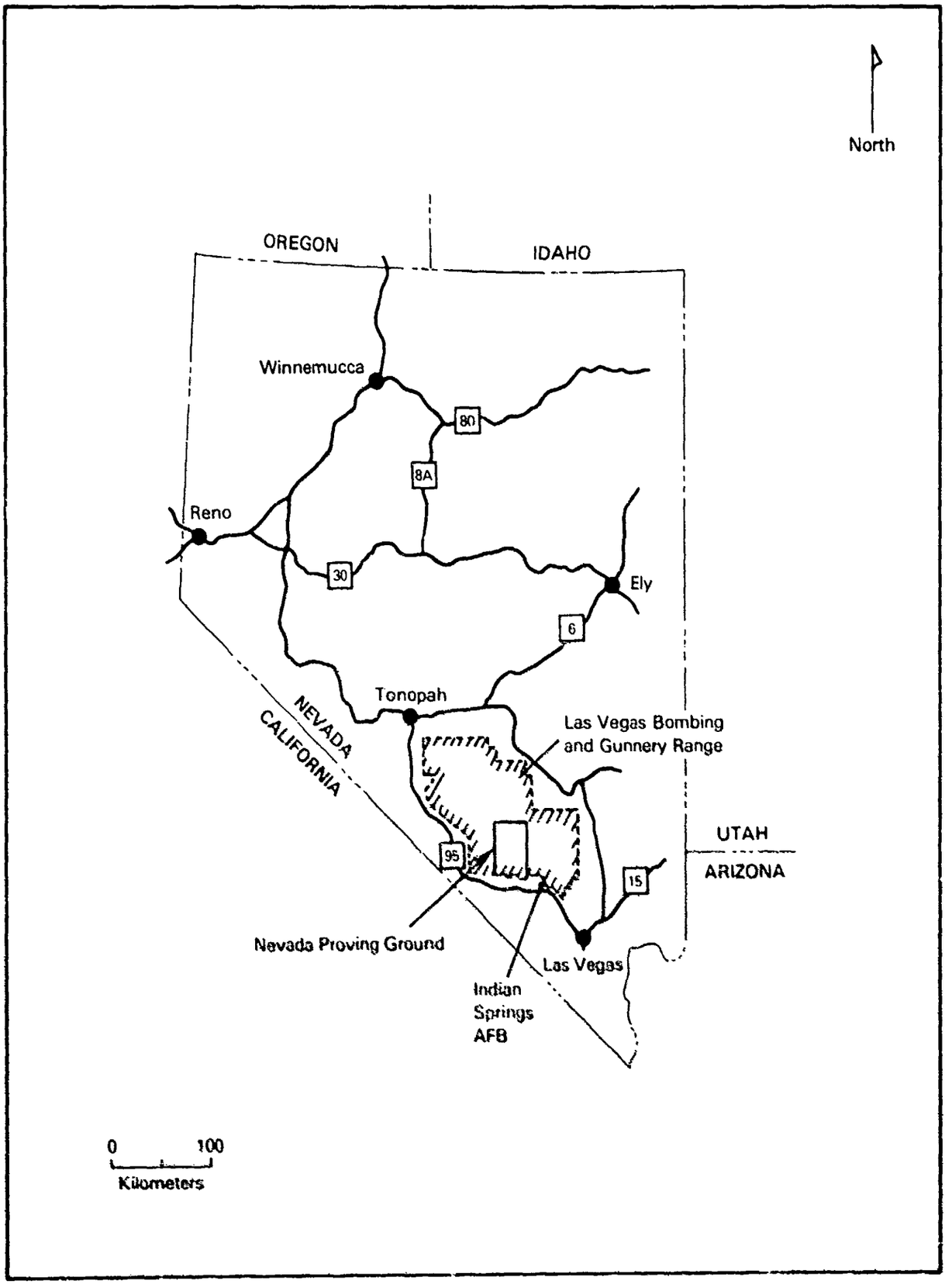

Figure 1-1: LOCATION OF NEVADA PROVING GROUND

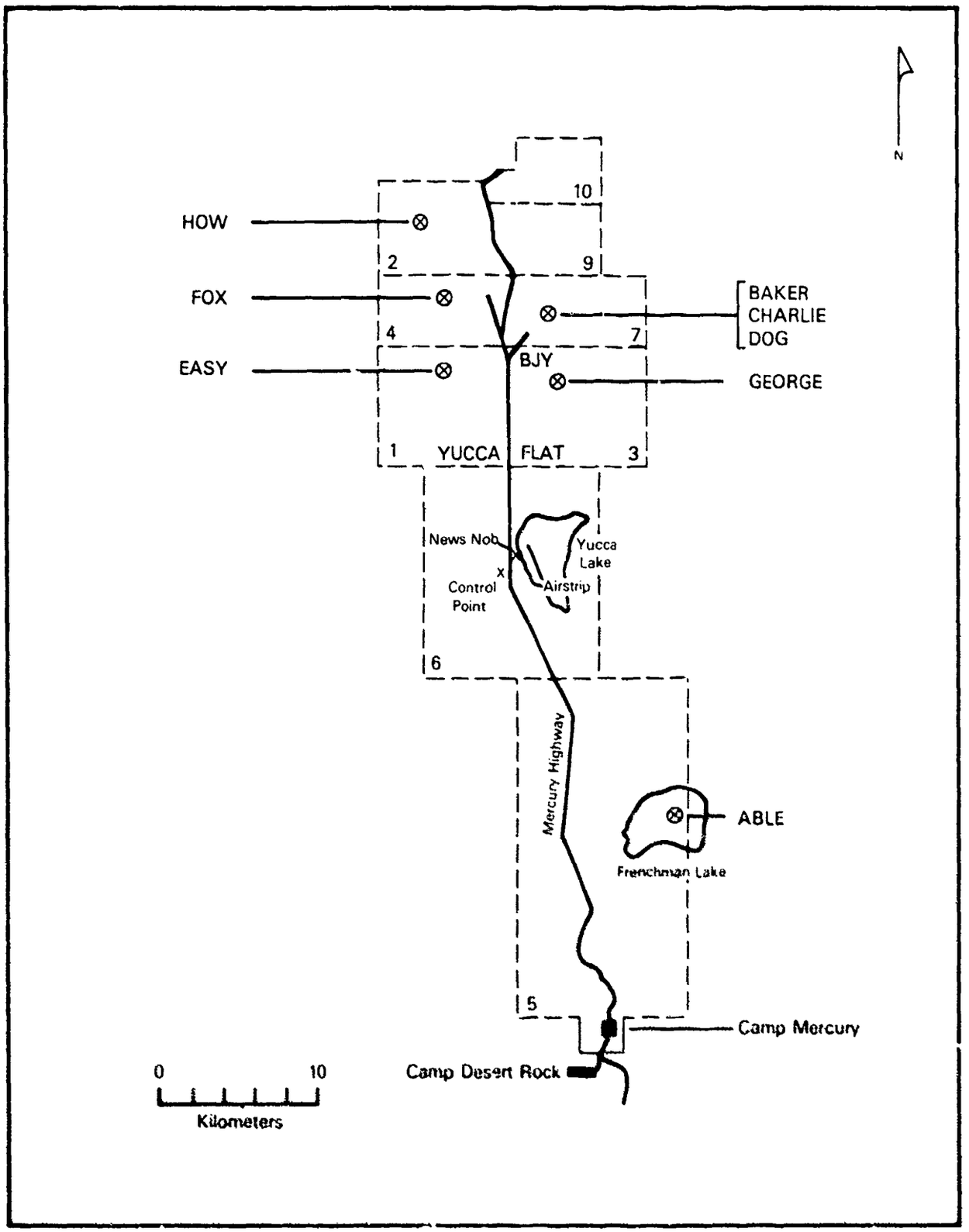

Figure 1-2: GROUND ZEROS FOR OPERATION TUMBLER-SNAPPER AT THE NEVADA PROVING GROUND

seven TUMBLER-SNAPPER tests. The area boundaries outlined in figure 1-2 approximate the testing areas. Frenchman Flat, which includes a 22-square-kilometer dry-lake basin, is located in the southeastern part of the NPG. Only one TUMBLER-SNAPPER event, Shot ABLE, was conducted in this area. Yucca Flat and Frenchman Flat are linked by Mercury Highway, which runs north and south through Yucca Pass. Yucca Pass is the site of News Nob, a major observation area, and the Control Point. The Control Point, consisting of several permanent buildings, was situated on the west side of Yucca Pass. Power, timing, and firing cables led from Control Point Building 1 to each test area in Yucca Flat and Frenchman Flat. All tower shots were detonated from Building 1, since that location allowed observation of the forward areas of Yucca Flat to the north and Frenchman Flat to the southeast. Decontamination facilities for personnel and vehicles returning from some of the testing areas were also at the Control Point (133).

Camp Mercury, at the southern boundary of the Nevada Proving Ground, was the base of TUMBLER-SNAPPER management operations for the joint AEC-DOD organization. Camp Mercury, shown in figure 1-3, provided office and living quarters, as well as laboratory facilities and warehouses, for the temporary and permanent personnel participating in various AEC test activities.

Indian Springs Air Force Base (AFB), 30 kilometers east of Camp Mercury, was the principal staging base for Air Force Special Weapons Center* (AFSWC) aircraft taking part in TUMBLER-SNAPPER.

Camp Desert Rock, headquarters of the Desert Rock exercises, was located just off the Nevada Proving Ground, three kilometers southwest of Camp Mercury. Camp Desert Rock consisted of quonset

*Before 1 April 1952, the Air Force Special Weapons Center was called the Air Force Special Weapons Command (8).

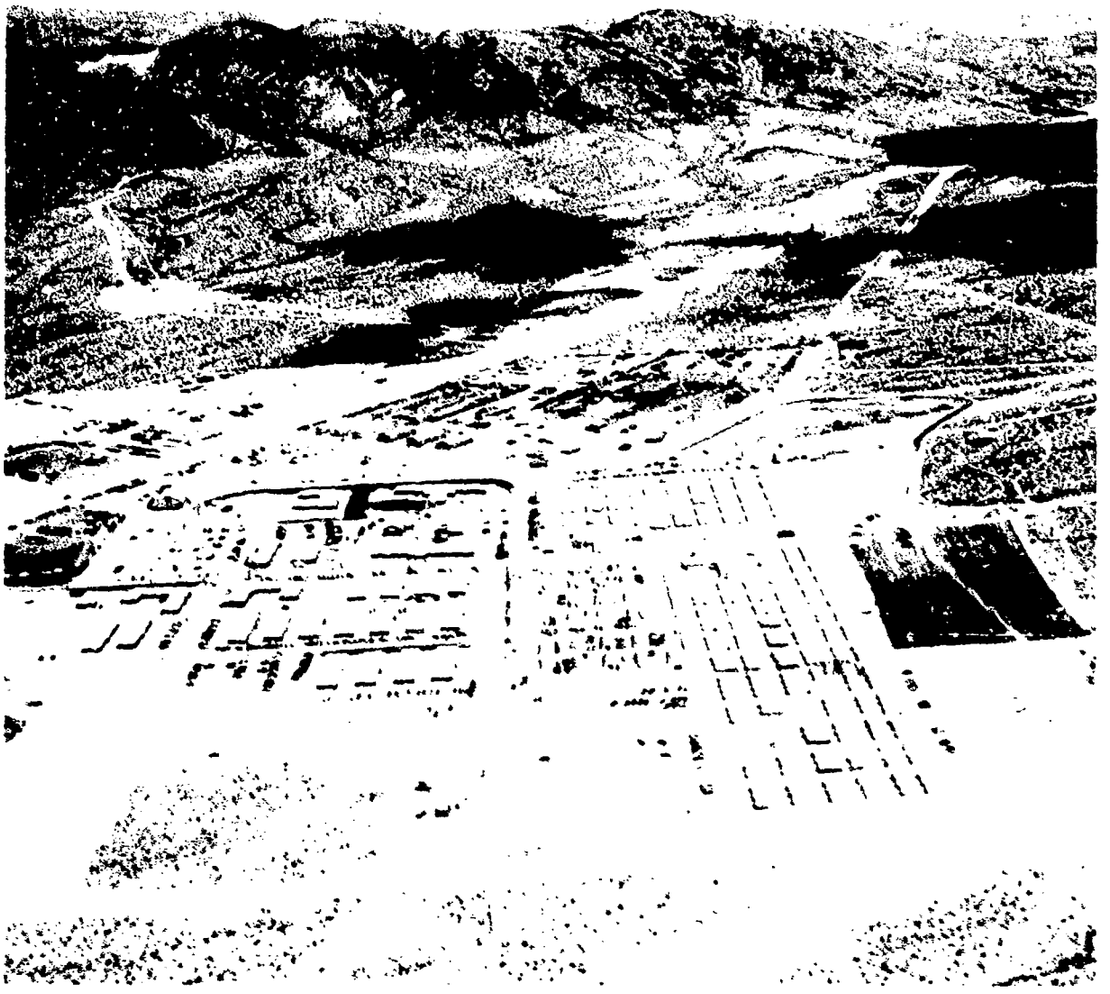

Figure 1-3: CAMP MERCURY AS IT APPEARED DURING THE 1950s

huts and semi-permanent structures augmented by trailers and tents as necessary. The camp population varied considerably, depending on the schedule of weapons tests and associated troop maneuvers. When tests were not being conducted, fewer than 100 people maintained the camp. During test periods, however, Camp Desert Rock often housed several thousand DOD personnel temporarily assigned to participate in the nuclear weapons tests (98; 133; 138).

1.4 SUMMARY OF OPERATION TUMBLER-SNAPPER EVENTS

During the planning for Operation TUMBLER-SNAPPER the AEC directed the Los Alamos Scientific Laboratory, an AEC weapons development laboratory, and the Department of Defense to indicate experimental areas that could be addressed during the 1952 test series. Their responses, when analyzed and evaluated, resulted in the scheduling of events listed in table 1-1. Beginning on 16 March, rain and snow in the test areas caused difficulties for workers constructing experiment stations and installing equipment. Despite these unfavorable weather conditions, the first TUMBLER-SNAPPER detonation, Shot ABLE, occurred on 1 April as scheduled.

Shot ABLE, an airdrop, was detonated over Frenchman Lake in Area 5. The other seven shots were detonated in five of the seven Yucca Flat shot areas. BAKER, CHARLIE, and DOG, also airdrops, had the same ground zero in Area 7. The height of detonation for the airdrops ranged from 793 feet* (Shot ABLE) to 3,447 feet (Shot CHARLIE). The other four devices were detonated on 300-foot towers in other shot areas. The detonations ranged in yield from two shots of one kiloton each, ABLE and BAKER, to the 31-kiloton Shot CHARLIE. Shots CHARLIE, DOG, FOX, and

*In this report, vertical distances are expressed in feet. Altitudes are usually stated from mean sea level, while heights are usually measured from the surface.

GEORGE, which involved Desert Rock activities, engaged the largest numbers of DOD participants (8; 73; 87; 138).

1.5 DEPARTMENT OF DEFENSE PARTICIPANTS AND ACTIVITIES

An estimated 10,600 DOD personnel, both military and civilian, from the armed services and the Armed Forces Special Weapons Project, participated at Operation TUMBLER-SNAPPER. They took part in the following activities:

- Joint AEC-DOD organization administration and support
- Test group scientific and diagnostic activities, including those of the Armed Forces Special Weapons Project
- Exercise Desert Rock IV troop activities and support
- Air support.

Although the AEC was responsible for planning, coordinating, and executing the programs and activities associated with Operation TUMBLER-SNAPPER, DOD personnel assisted the AEC Test Manager in these duties. The DOD personnel attached to the joint AEC-DOD organization were responsible for overseeing DOD's technical and military planning objectives.

DOD personnel also participated in the scientific and diagnostic projects conducted by two test groups at Operation TUMBLER-SNAPPER. The Military Effects Test Group, directed by Test Command, AFSWP, involved more DOD participants than the Weapons Development Test Group, which was directed by the AEC. Drawn from various DOD laboratories, these participants conducted experiments to learn more about weapons effects. Activities of the AEC Weapons Development Test Group were conducted primarily by the Los Alamos Scientific Laboratory, but DOD personnel were sometimes involved.

Participants in test group projects generally placed instruments and experimental material around the intended ground zero in the days and weeks before the scheduled detonation. After the detonation, when the Test Manager had determined that the radiological environment in the shot area would permit access, they returned to recover the equipment. During a detonation, project personnel were generally positioned at designated observer locations or were operating equipment or aircraft at substantial distances from ground zero.

Observation programs involving DOD personnel were conducted through the Exercise Desert Rock IV programs at Shots CHARLIE, DOG, FOX, and GEORGE. The Desert Rock IV programs usually involved the greatest number of DOD participants at any one shot. These activities generally included orientation and indoctrination programs, highlighted by the observation of a nuclear burst. At Shots CHARLIE, DOG, and GEORGE, Exercise Desert Rock IV also included tactical troop maneuvers after the detonations.

Approximately 1,500 soldiers from various Army units provided support for the Exercise Desert Rock programs. They maintained and operated Camp Desert Rock, an installation of the Sixth Army. Some of the Desert Rock support troops worked in the forward areas of the NPG to construct observer trenches, lay communication lines, provide transportation, and assist in other preparations for Desert Rock IV activities. Many of the Camp Desert Rock support personnel observed at least one nuclear test during Operation TUMBLER-SNAPPER, and some were called upon to perform support or staff duties in the test areas during detonations.

Finally, DOD personnel provided air support for the Test Manager and the test groups. Personnel of the Air Force Special Weapons Center conducted cloud sampling, sample courier missions, cloud tracking, aerial surveys of the terrain, and other air support as requested. AFSWC consisted of units of the 4925th Test Group (Atomic) and the 4901st Support Wing (Atomic). Although these units were based at Kirtland AFB, New Mexico, they staged out of Indian Springs AFB during the testing.

CHAPTER 2

FUNCTIONS OF THE ADMINISTRATIVE ORGANIZATIONS DURING OPERATION TUMBLER-SNAPPER

Two groups, the joint AEC-DOD organization and Exercise Desert Rock IV, conducted major activities during Operation TUMBLER-SNAPPER. These groups were established to plan, manage, and coordinate the eight weapons tests, the scientific and diagnostic experiments, and the military training maneuvers (138; 148).

Representatives from both the Atomic Energy Commission and the Department of Defense staffed and administered the joint AEC-DOD organization. The primary responsibilities of this organization were to schedule and detonate the nuclear devices and to evaluate the results of each detonation. The Test Manager and his staff performed the first function, while the Test Director and his staff were responsible for the second. Section 2.1 of this chapter describes the roles and responsibilities of both the Test Manager and the Test Director (8; 25; 138).

Exercise Desert Rock IV was staffed and administered by the Army and included personnel from the Department of Defense and the armed services. Exercise Desert Rock IV functioned separately from the joint organization, but liaison was established between the two groups to ensure that Desert Rock training programs did not interfere with the scientific programs of the joint organization. Throughout Operation TUMBLER-SNAPPER, Army support troops resided at Camp Desert Rock, just south of the Nevada Proving Ground. These troops provided such support as security and law enforcement, radiological safety, medical care, transportation, construction, food, and laundry. Exercise troops from the Army, Navy, and Marine Corps were assigned to Camp Desert Rock for periods of a few days to participate in a particular training program (98; 108).

In addition to DOD personnel, participants in Operation TUMBLER-SNAPPER included employees of other Federal agencies, research laboratories, and private firms under contract to the Government. Department of Defense personnel participated in the activities of many of these organizations (119; 138; 148).

2.1 THE JOINT AEC-DOD ORGANIZATION

The Atomic Energy Commission and the Department of Defense shared responsibility for planning and implementing the U.S. atmospheric nuclear weapons test program. The AEC was responsible for exploring and developing new areas of nuclear weapons technology, while the DOD was to incorporate the weapons into the military defense program (12; 131).

Congress established the Atomic Energy Commission in 1946 with the passage of the Atomic Energy Act. In addition to stipulating the purposes of the AEC, which included exploring the uses of atomic energy as well as developing nuclear weapons technology, the Act provided for the President to appoint five commissioners and a general manager as the chief administrators of the Commission. The Atomic Energy Act also established four divisions within the AEC (1; 12):

- Research
- Production
- Engineering
- Military Application.

The Director of the Division of Military Application, who was a member of the armed services, delegated his onsite responsibility for test preparations at the Nevada Proving Ground to the manager of the AEC Santa Fe Operations Office. This responsibility included overseeing the preparations for Operation TUMBLER-SNAPPER at the NPG. The Director of Military Application coordinated tasks with the various divisions of the AEC Santa Fe

Operations Office, as well as with AEC Field Managers, nuclear weapons development laboratories, the Department of Defense Armed Forces Special Weapons Project, and other Government agencies. Before Operation TUMBLER-SNAPPER, the Director of the Division of Military Application appointed the manager of the Santa Fe Operations Office to be the Test Manager of the joint AEC-DOD organization at the Nevada Proving Ground. Figure 2-1 shows the structure of the joint organization and Exercise Desert Rock IV and their relationship to each other within the Federal Government (8; 15; 23; 25).

During the planning phase of TUMBLER-SNAPPER, the President relied on the Secretary of Defense to coordinate the activities of the various armed services through the Joint Chiefs of Staff. The Armed Forces Special Weapons Project was the principal agency within the Department of Defense for developing nuclear weapons. AFSWP had been created in January 1947 by a Memorandum Order signed by the Secretaries of War and the Navy (8; 15; 16).

The Chief of AFSWP ordered the establishment of Test Command, AFSWP, effective on 29 January 1952. Within the continental United States, the unit was to exercise technical direction of weapons effects tests of primary concern to the Armed Forces and coordinate military activities supporting the AEC in conducting the tests (8; 21; 23; 25).

The commander and the first personnel assigned to the Test Command were from the Air Force Special Weapons Command (which became the Air Force Special Weapons Center in April 1952) at Kirtland AFB. Additional personnel were assigned by the armed services. During TUMBLER-SNAPPER, the Test Command consisted of 53 Army, 16 Navy, and 18 Air Force personnel.

The commander of Test Command, who reported directly to the Chief of AFSWP, was responsible for technical direction of

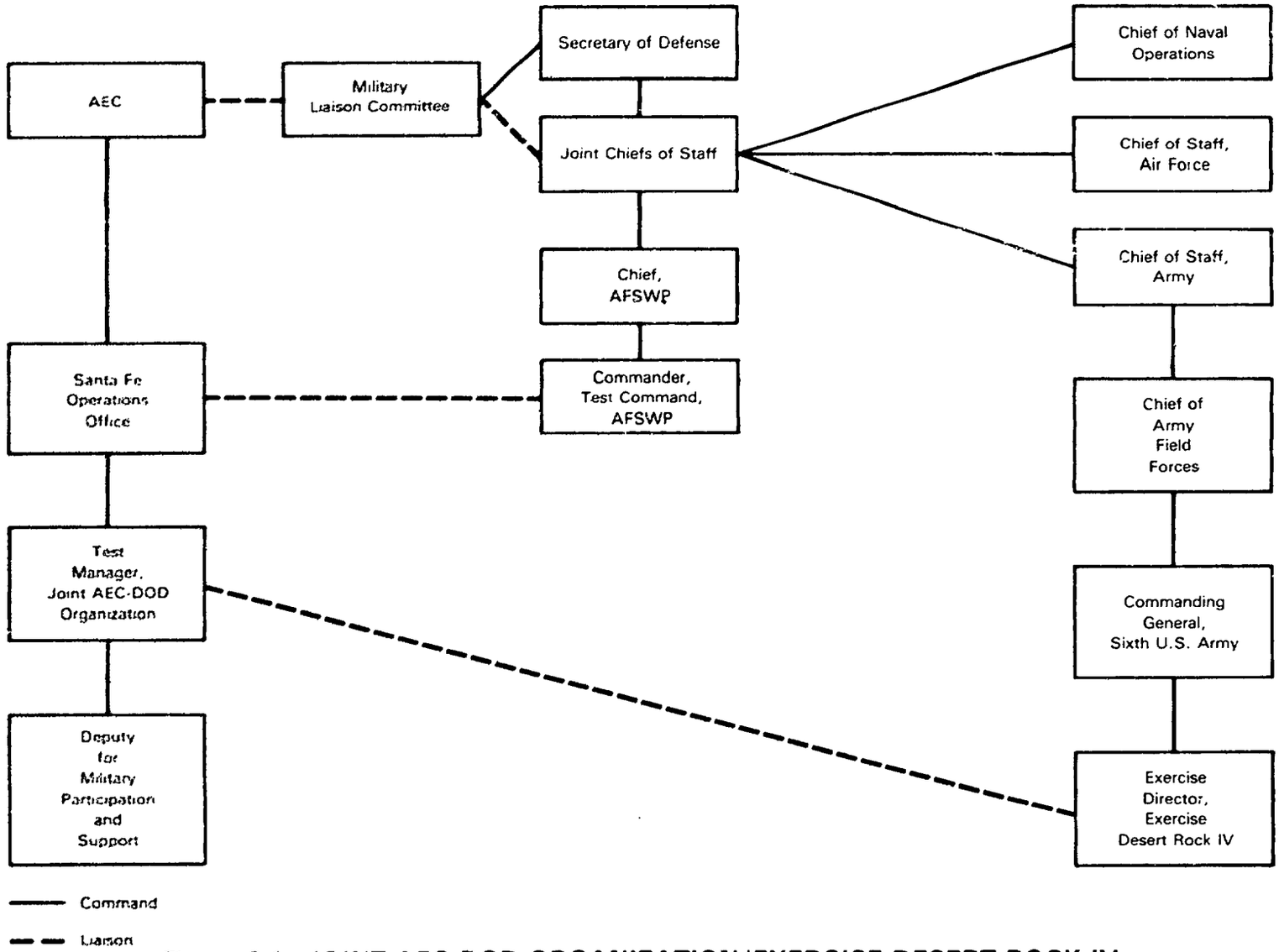

Figure 2-1: JOINT AEC-DOD ORGANIZATION/EXERCISE DESERT ROCK IV STRUCTURE WITHIN FEDERAL GOVERNMENT

weapons effects tests of primary concern to the Armed Forces. In addition, he was to coordinate all military participation and assist the AEC in meeting its schedule for the weapons testing series. To this end, he established direct liaison with the manager of the Santa Fe Operations Office, as shown in figure 2-1 (8; 23; 25).

The Test Command commander and his staff arrived at Sandia Base on 4 March. They immediately began working out details of the Operation Plan, which they issued on 17 March. On 20 March, the commander met with the Desert Rock IV Exercise Director to discuss military operations before the Exercise Director issued a detailed plan for the shots. This meeting was followed by further discussions about the operational phases of the shots (8; 23; 36; 42).

The Test Command commander was the Deputy for Military Participation and Support on the Test Manager's staff. As such, he coordinated DOD activities at the Nevada Proving Ground. These activities included the scientific and diagnostic programs conducted by the AFSWP Military Effects Test Group, the training programs and troop maneuvers comprising Exercise Desert Rock IV, and the support activities of the Air Force Special Weapons Center. AFSWC was responsible for the operational control of all aircraft participating in Operation TUMBLER-SNAPPER. AFSWC also coordinated air support (8; 17; 19; 23; 25, 75).

As shown in figure 2-1, liaison between the AEC and the DOD existed at several points. The Atomic Energy Act provided for a Military Liaison Committee consisting of representatives from the Department of Defense to consult with the AEC on "the development, manufacture, use, and storage of bombs, the allocation of fissionable material for military research, and the control of information relating to the manufacture or utilization of atomic weapons." This committee was the primary liaison between the AEC and the DOD (1).

During the planning and implementation phases of Operation TUMBLER-SNAPPER, the Joint Chiefs of Staff coordinated the activities of Exercise Desert Rock IV through liaison with the Office, Chief of Army Field Forces, and the Commanding General of the Sixth U.S. Army, who served as the Exercise Supervisor for Exercise Desert Rock IV. The Exercise Director was appointed by the Commanding General, Sixth U.S. Army. At the operational level, the Test Manager's Deputy for Military Participation and Support coordinated Exercise Desert Rock IV activities with those of the joint organization (58; 108).

Personnel to staff the various elements of the joint organization were drawn from the AEC Santa Fe Operations Office, AEC contractors, and various DOD agencies. Excluding AFSWP and AEC personnel, 278 personnel participated in the activities of the organization. Of these personnel, 64 were from LASL (23; 119).

2.1.1 Test Manager's Organization

The Test Manager was responsible for the overall direction of Operation TUMBLER-SNAPPER. This responsibility included deciding whether or not to proceed with a shot as planned, coordinating the agencies involved in the weapons development and weapons effects projects, and supervising the staff units that performed support functions for the test participants. The Test Manager's staff is shown in figure 2-2 (8; 47; 158).

The Advisory Panel consisted of representatives from AFSWP Test Command and AFSWC and scientists from LASL. This panel briefed the Test Manager on weather conditions and their potential effects on the scheduled tests (8).

The Deputy for Scientific Programs provided technical supervision of all scientific projects conducted by the Military

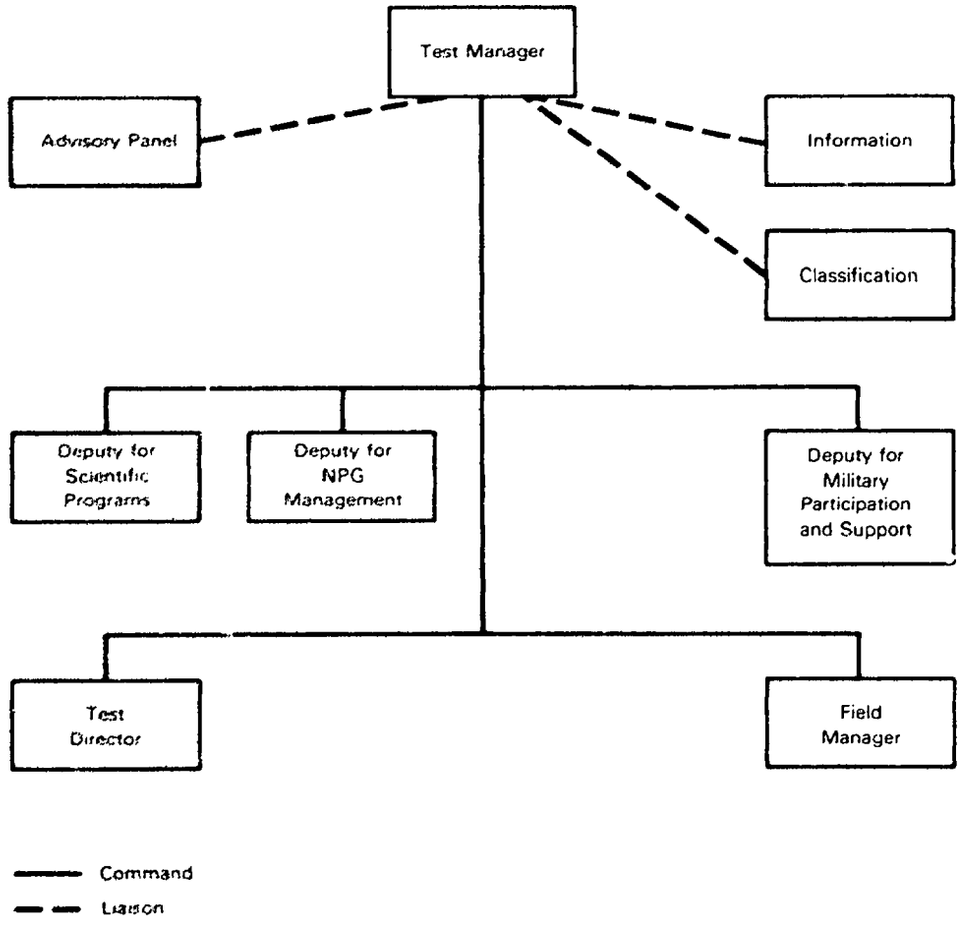

Figure 2-2: TEST MANAGER'S ORGANIZATION

Effects Test Group and the Weapons Development Test Group. This individual also served as the Test Director and had his own staff and duties, as described in the next section (8; 23).

The Deputy for Nevada Proving Ground Management provided for and supervised all auxiliary services required for operating the NPG during Operation TUMBLER-SNAPPER. He was also the Field Manager and, like the Test Director, had his own staff (8).

The Deputy for Military Participation and Support was the Test Manager's chief military advisor. He coordinated projects conducted by the Military Effects Test Group and military support provided by the radiological safety unit. In addition, he served as liaison between the Test Manager and the Exercise Director for Desert Rock activities. He was responsible for ensuring that Desert Rock activities did not interfere with test group projects (8; 23).

Among the other administrative offices included within the Test Manager's staff were the Information Office and the Classification Office. The Information Office was the first public relations office established for a continental nuclear weapons testing series. With offices at Camp Mercury and Las Vegas, Nevada, it was the central point for releasing information to the public about the nuclear detonations. The Special Assistant and Information Director managed the Information Office. The staff included information officers from the AEC, LASL, and the armed services. The Classification Office was administered by the AEC Security Chief. He was responsible for security matters at the Nevada Proving Ground, including personnel security. This responsibility involved the processing of security clearances for personnel at the NPG (8; 119).

2.1.2 Test Director's Organization

While the Test Manager and his staff provided the technical and administrative guidance necessary to conduct Operation TUMBLER-SNAPPER and its related activities, the day-to-day responsibility for preparing the nuclear devices and planning and implementing the scientific and diagnostic experiments was delegated to the Test Director, who was a scientist from LASL.

The daily planning and implementation of the many test programs performed by agencies and contractors of the AEC and DOD required close liaison between those agencies involved and the units within the Test Director's organization. The two main positions on the Test Director's staff were the Deputy for Military Effects Tests and the Deputy for Weapons Development Tests. The Deputy for Military Effects Tests directed eight programs designed to measure the weapons effects characteristics of each nuclear device detonated. The Deputy for Weapons Development Tests conducted scientific and diagnostic experiments to evaluate the nuclear devices (8).

As shown in figure 2-3, the Test Director's organization included several subsections responsible for technical information, classification, engineering and construction, plans and operations, administration and personnel, and logistics and supply. Consisting of representatives from various DOD and AEC agencies, the subsections provided services to both the Military Effects Test Group and the Weapons Development Test Group (8).

Other units provided support services to the Test Director. These subsections, shown in figure 2-3, included:

- Weather
- Timing and Firing
- Weapons Assembly
- Radiological Safety
- Documentary Photography

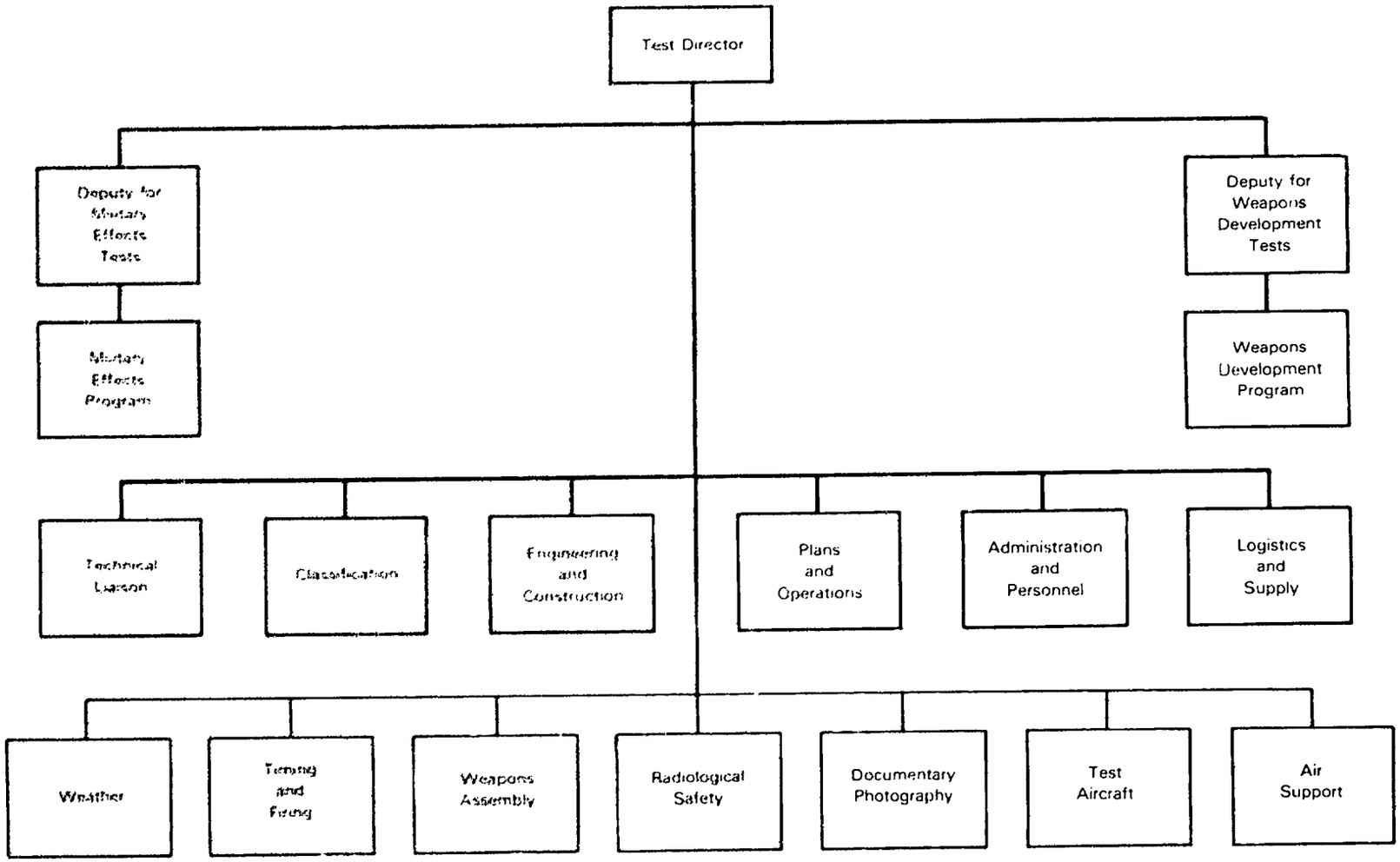

Figure 2-3: TEST DIRECTOR'S ORGANIZATION

- Test Aircraft
- Air Support.

The Air Force Air Weather Service provided the Test Director with meteorological information important in scheduling the detonations, such as specific data on wind and cloud conditions. The 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma, directed the meteorological analysis from the Control Point Weather Station and stations in the surrounding area. Eight forecasters, 13 observers, and 14 other Air Force personnel operated special equipment at the Control Point. An additional 11 Air Force personnel operated a station at Tonopah, Nevada, as did three Air Force personnel at each of the following locations: Beatty, Caliente, Crystal Springs, Currant, and Warm Springs, Nevada, and St. George, Utah. The 6th Weather Squadron was assisted by a consultant from Andrews AFB, Maryland, who aided the forecasters in their meteorological analysis at the beginning of TUMBLER-SNAPPER. The activities of the Air Force Air Weather Service are described in chapter 4 (8; 112).

The Timing and Firing Unit, which included personnel from Edgerton, Germeshausen, and Grier, Inc. (EG&G), provided instruments and apparatus for setting the timing of the detonations and for firing the nuclear devices detonated on the 300-foot towers (8; 119). The four airdropped devices were detonated by their own internal fusing and firing systems.

The Weapons Assembly Unit, which included personnel from the AEC, LASL, and AEC contractors, assembled the nuclear components of the TUMBLER-SNAPPER devices. The devices for the tower detonations were assembled at the NTG, while the airdropped devices were assembled at Kirtland AFB, New Mexico (8).

The Radiological Safety Group supervised onsite and offsite radiological safety activities at TUMBLER-SNAPPER. The Onsite

Operations Officer was responsible for the area within a 32-kilometer radius of the shot site. He and his staff issued film badges, directed monitoring activities, and briefed recovery and decontamination personnel before their postshot entry into the shot area. The Offsite Operations Officer was responsible for radiological safety activities within a 320-kilometer radius of the onsite area. He and his staff supervised ground surveys, collated cloud-tracker data, maintained liaison with the Air Weather Service and the Civil Aeronautics Administration, and managed an information center. The offsite operations staff included a representative from the Civil Aeronautics Administration whose office was in the Air Operations Center. This representative determined the airways to be closed or opened to commercial aircraft on shot-days. The Radiological Safety Group, consisting of 30 officers and 167 enlisted men from the Army, Navy, and Air Force, is discussed in further detail in section 5.2 of this volume, Radiation Protection for the Joint AEC-DOD Organization (8; 91).

The Air Force 1352nd Motion Picture Squadron, Air Photographic and Charting Service, from Lookout Mountain Laboratory in Hollywood, California, provided motion picture and still photography coverage of the scientific and technical programs. It also supplied photographs to the Test Information Office (8).

The Test Aircraft Unit was responsible for coordinating and supervising the air operations directly related to the TUMBLER-SNAPPER nuclear tests. This unit directed the 4925th Test Group (Atomic) from AFSWC in such activities as cloud sampling, cloud tracking, aerial radiation surveys of the terrain, aerial photography missions, and other air operations designed to collect experimental data. The 4925th Test Group (Atomic) had operational control over all aircraft participating in Operation TUMBLER-SNAPPER (8; 25; 82; 119).

The Air Support Unit was responsible for coordinating and supervising the air operations that were not a direct part of the TUMBLER-SNAPPER tests but were of a support nature. The 4901st Support Wing of AFSWC, based at Kirtland AFB, and other Air Force units provided air support. These activities included flying air transport and courier missions between Kirtland AFB and Indian Springs AFB, furnishing aircraft and crews for certain Test Aircraft Unit operations, maintaining airbase facilities at Kirtland and Indian Springs, and providing other support as requested (8; 25; 82; 109; 119). AFSWC activities are described in more detail in chapter 4.

The Test Director's technical advisors and support personnel planned and conducted the day-to-day test activities. The technical advisors reviewed the proposed activities for each program and project of the different laboratories and agencies. Working with the representatives of the support group and the technical advisors, the Test Director and his staff revised the proposed plans to include scheduling, construction locations, supplies, transportation, radiological safety, air support, and postshot recovery operations. The Test Director and his staff presented these revised plans to the Test Manager, who had final authority to review and approve activities associated with Operation TUMBLER-SNAPPER.

2.1.3 Field Manager's Organization

The Field Manager, who was an AEC employee, and his organization, shown in figure 2-4, were responsible for auxiliary services required for construction and maintenance of the Nevada Proving Ground and Camp Mercury. These services included administration; operations, which included construction and camp maintenance and transportation; communications; and security (8).

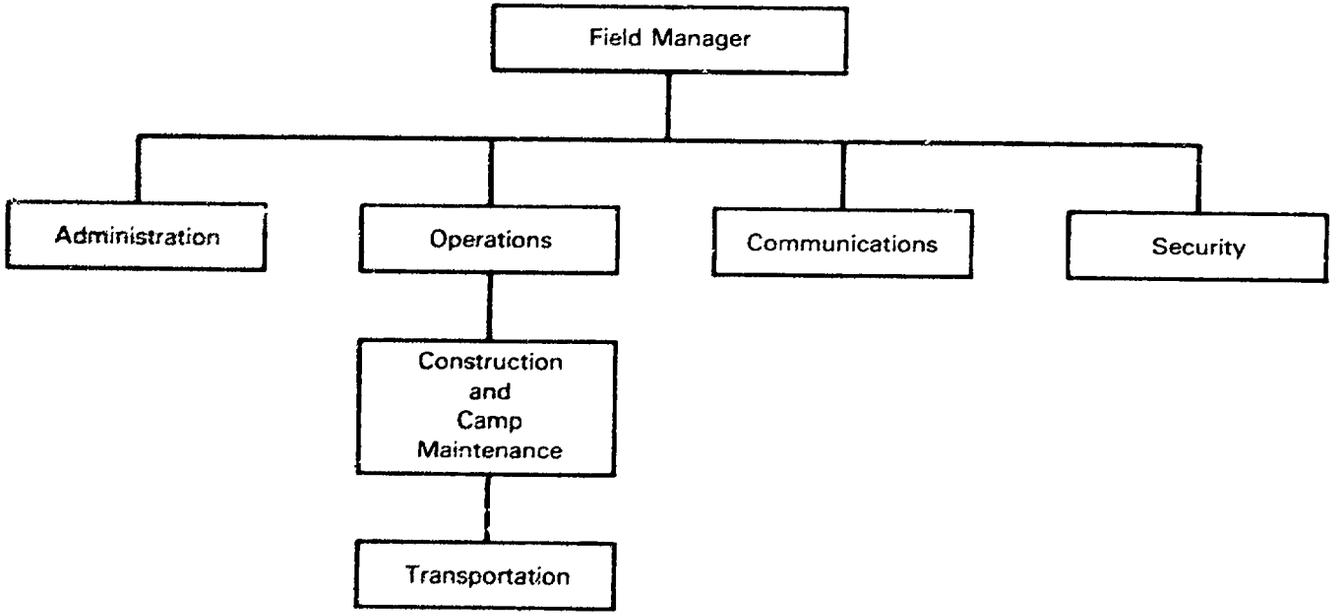

Figure 2-4: FIELD MANAGER'S ORGANIZATION

2.2 THE ORGANIZATION OF EXERCISE DESERT ROCK IV

Exercise Desert Rock troops were at Operation TUMBLER-SNAPPER through an agreement between the AEC and DOD. Although Exercise Desert Rock IV had its own administrative structure, described below, the Test Manager influenced Exercise Desert Rock activities in several ways. The Test Manager reviewed and approved all program activities associated with the nuclear tests at the NPG, including Desert Rock activities. At the time of Operation TUMBLER-SNAPPER, he was also responsible for the radiological safety of Exercise Desert Rock participants (8; 14; 36; 63).

Exercise Desert Rock IV, which was sponsored by the Department of the Army, involved an estimated 7,350 DOD participants in observation activities and tactical troop maneuvers. About 1,500 military personnel were needed to support the exercises and coordinate Desert Rock activities with the activities and programs of the joint AEC-DOD organization.

Headquarters for Exercise Desert Rock IV was formally established in the spring and summer of 1952. The Commanding General of the Sixth U.S. Army was appointed Exercise Supervisor. In planning and conducting Exercise Desert Rock IV operations, the Exercise Supervisor was responsible for Army, Navy, Marine Corps, and Air Force personnel and for providing administrative and logistical support to the exercise troops. During the planning phases, the Exercise Supervisor conferred with representatives from the AEC Santa Fe Operations Office and from the AFSWP Test Command to ensure that Exercise Desert Rock activities did not conflict with test group projects (8; 63; 106; 108; 120; 160).

Throughout both the planning and operational phases of Exercise Desert Rock IV, the Exercise Supervisor maintained his offices at the Sixth U.S. Army headquarters, located at the Presidio in San Francisco. At the Nevada Proving Ground, the

Exercise Supervisor was represented by his deputy, who was designated Exercise Director and Commander of Camp Desert Rock. The Exercise Director was at Camp Desert Rock during the operational phase of the exercises (98; 106; 108).

The Exercise Director's staff had the standard organization, with S-1, S-2, S-3, S-4, and special staff sections. Two additional special staff sections, the Radiological Safety Group and the Instructor Group, were added to the standard organization to provide services not performed by the regular staff (97, 106; 108). Figure 2-5 depicts the probable organization of the Exercise Director's staff.

The Chief of Staff was responsible for directing the Desert Rock staff, while the Executive Officer for Operations coordinated Desert Rock IV activities. The Executive Officer for Administration provided the Exercise Director with clerical and administrative support and also supervised the Camp Desert Rock Visitors' Bureau. The Inspector General reviewed both support and exercise troop activities to ensure compliance with established military procedures. The Public Information Officer distributed press releases concerning Desert Rock activities to national news organizations and to the hometown newspapers of participating troops. The Judge Advocate provided legal services for Exercise Desert Rock IV. The Headquarters Commandant was responsible for maintaining and operating Camp Desert Rock (106; 108).

Staff units for administration, security and intelligence, operations, and logistics and Special Staff Officers provided services necessary for operating the camp and for conducting the Desert Rock exercises (106-108).

The S-1 Section, Administration, established personnel management and other administrative policies for Camp Desert Rock (106; 108).

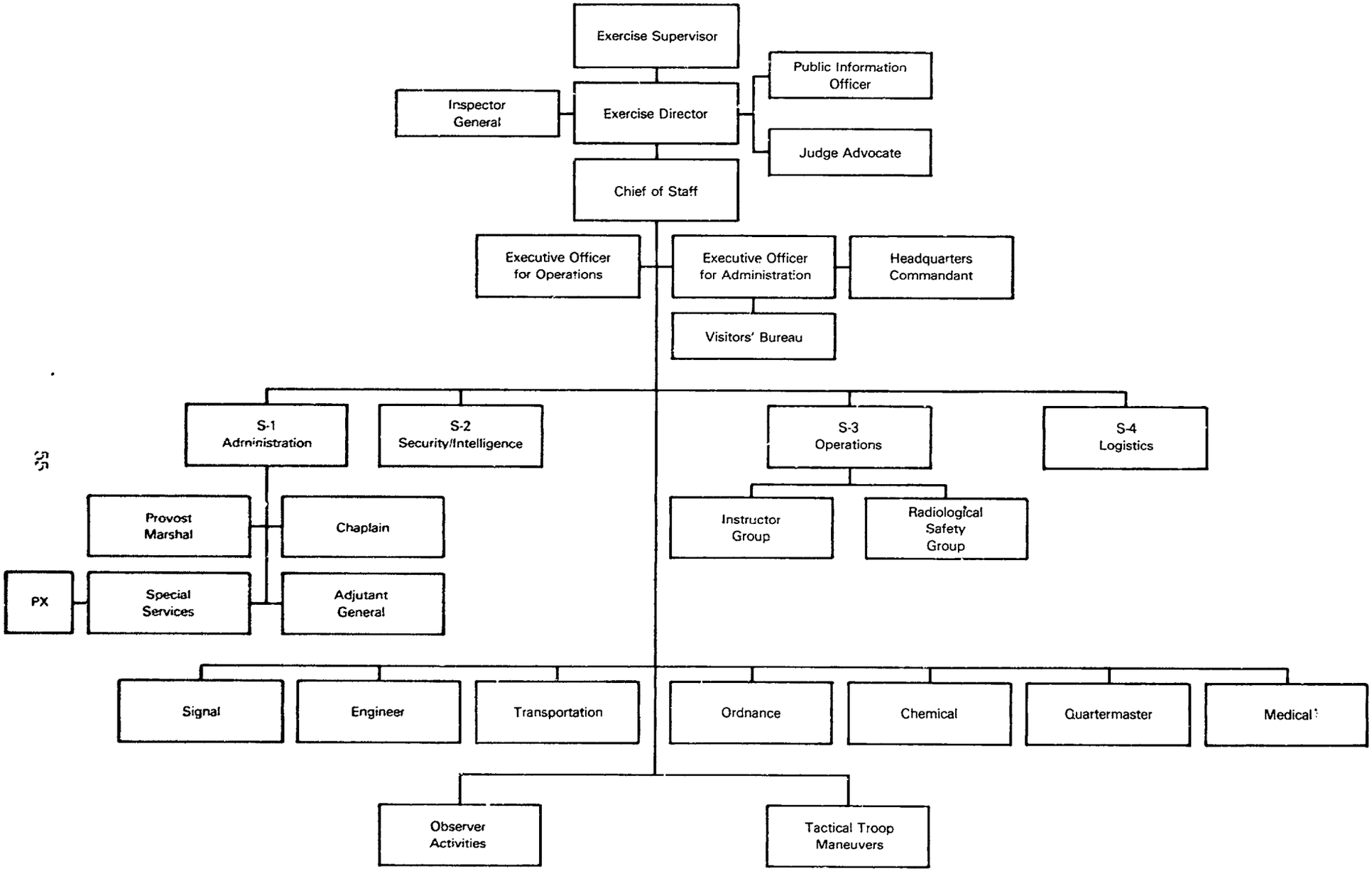

Figure 2-5: CAMP DESERT ROCK ORGANIZATION, EXERCISE DESERT ROCK IV, 1952

The Adjutant General provided mail service to all troops through the Postal Branch, maintained a headquarters message center, and furnished messenger service to the headquarters staff sections. The Adjutant General's office also kept personnel records and maintained personnel strength at the camp by requisitioning through its Personnel Branch to the Sixth Army. Throughout Exercise Desert Rock IV, however, there was a shortage of administrative and clerical personnel (105; 106; 108).

The Provost Marshal's Office provided law enforcement and traffic control at Camp Desert Rock. The Provost Marshal was assigned from Headquarters, Sixth Army. The Provost Marshal exercised staff supervision of Company A, 505th Military Police Battalion, which was assigned to Camp Desert Rock. This unit operated the main gate to the camp, provided law enforcement within the camp, conducted patrols in downtown Las Vegas, and provided traffic control in the forward area on shot-days in conjunction with Desert Rock maneuvers. The Chaplain provided counseling and religious services at the camp. Special Services provided the entertainment and recreation program for Desert Rock personnel and operated the Post Exchange (106; 108).

The S-2 Section, Security and Intelligence, was responsible for security safeguards for all classified material connected with Exercise Desert Rock IV and for ensuring that all personnel had proper security clearances. The S-2 Section maintained close liaison with the Security Branch of the joint AEC-DOD organization (8; 106-108).

The S-3 Section, Operations, was responsible for planning, coordinating, and conducting Camp Desert Rock operations and exercise activities. The Radiological Safety Group and the Instructor Group provided the S-3 section with special services required for Exercise Desert Rock IV.

The Radiological Safety Group established the radiological safety procedures used to limit the exposure of Desert Rock exercise troops entering the forward area. The Desert Rock Radiological Safety Group was independent of the AFSWP radiological safety group but conducted some activities under the direction of the AFSWP group with the assistance of the 216th Chemical Service Company which was attached to AFSWP. After each shot, Desert Rock radiological safety monitors accompanied troops into the forward area; conducted ground radiological surveys; monitored trenches, equipment displays, and troop maneuver areas; and decontaminated Desert Rock personnel leaving the forward area. Chapter 5 of this volume describes Desert Rock radiological safety activities in more detail (8; 14; 42; 91; 106; 108; 160).

The Instructor Group conducted the orientation program for incoming troops and observers and briefed personnel on the objectives of Exercise Desert Rock IV, the capabilities of nuclear weapons, and the protective measures to take against the blast, thermal, and radiation effects of a nuclear detonation. The instructors were from the Sixth Army and AFSWP (8; 106; 108; 160).

The S-4 Section, Logistics, was responsible for providing logistical services to Camp Desert Rock and the exercise troops (106; 108; 160).

Special staff sections were responsible for the technical areas indicated in figure 2-5 (8; 108; 160).

The Signal Section was responsible for advising the Exercise Director on all signal activities at Camp Desert Rock and for supervising the Camp Desert Rock Signal Corps Detachment. This detachment, composed of personnel from the 314th Signal Construction Battalion and the 504th Signal Base Maintenance Company,

established wire and radio communications within the test areas and at Camp Desert Rock. The Signal Section was also responsible for issuing and collecting film badges (8; 105; 106; 108).

The Engineer Section supervised elements of the 369th Engineer Amphibious Support Regiment, which constructed trenches, equipment displays, and other projects in the forward area of the NPG and at Camp Desert Rock (106; 108).

The Ordnance Section supervised personnel from an ordnance detachment attached to the 369th Engineer Amphibious Support Regiment. This section procured, distributed, and maintained weapons and vehicles for the exercise troops and equipment displays (8; 106; 108).

The Quartermaster procured food, clothing, and other supplies for Camp Desert Rock (106; 108).

The Transportation Section was responsible for transporting test equipment, supplies, observers, and Desert Rock exercise troops to and from the forward area. This section supervised the 23rd and 31st Transportation Truck Companies and the 562nd Transportation Staging Area Company (105; 106; 108).

The Chemical Section was responsible for coordinating radiological safety operations in Camp Desert Rock during and after a nuclear detonation. This was accomplished through Sixth Army Chemical, Biological, and Radiological teams, which were part of the Desert Rock Radiological Safety Group (8; 106; 108).

The Medical Section, staffed by a medical detachment from the Sixth Army, provided medical aid for Camp Desert Rock and established temporary medical aid stations at trench and forward parking areas. Medical personnel from the 1st Armored Division assisted during portions of the exercise (8; 105; 106; 108).

Because Exercise Desert Rock IV involved many more DOD participants than did the joint AEC-DOD organization, the activities of the Exercise Desert Rock troops are described first, in chapter 3. A description of DOD participation in the joint organization activities follows in chapter 4.

CHAPTER 3

EXERCISE DESERT ROCK IV PROGRAMS AT OPERATION TUMBLER-SNAPPER

According to estimates compiled by the armed services, approximately 10,600 DOD civilian and military personnel took part in Operation TUMBLER-SNAPPER. Of these, an estimated 7,350 individuals participated in Exercise Desert Rock IV activities conducted by the Sixth Army.

Exercise Desert Rock IV was designed to train maneuver units in the effects of nuclear weapons. The objectives were to (108):

- Provide training in the tactical use of nuclear weapons
- Observe psychological responses to nuclear detonations
- Provide information on radiological safety measures
- Provide training in the effects of a nuclear detonation on ordnance materiel and military equipment.

While its objectives were similar to those of previous Desert Rock exercises, Desert Rock IV differed in certain respects. For example, the AEC gave the Army greater responsibility for radiological safety. In addition, the AEC and DOD authorized troops to be positioned closer to ground zero to observe the shot and to conduct postshot activities; observers were allowed to witness the nuclear detonations from positions 6,400 meters from ground zero (71; 108; 120).

Department of Defense personnel involved in Exercise Desert Rock IV were assigned to Camp Desert Rock. DOD personnel at Camp Desert Rock were divided into two groups: Camp Desert Rock support troops and Desert Rock IV exercise troops (98; 108).

Camp Desert Rock Support Troops

Camp Desert Rock support troops numbered about 1,500 at Operation TUMBLER-SNAPPER. These troops were drawn primarily from the Sixth Army units listed below:

- Headquarters and Headquarters and Service Company, 369th Engineer Amphibious Support Regiment
- Shore Battalion, 369th Engineer Amphibious Support Regiment
  - -- Company D
  - -- Company E
  - -- Company F
- 562nd Transportation Staging Area Company (minus one platoon)
- 23rd Transportation Truck Company
- 31st Transportation Truck Company
- Company A, 505th Military Police Battalion
- Detachment, 314th Signal Construction Battalion
- Detachment, 504th Signal Base Maintenance Company
- Detachment, 3623rd Ordnance Medium Company
- Medical Detachment, Sixth Army
- 360th Army Band.

These units were generally stationed at the camp throughout the test series. They provided support services to the exercise troops, as described in chapter 2 (2-7; 98; 108).

In addition to their duties at Camp Desert Rock, some support units entered the forward testing areas of Yucca Flat and Frenchman Flat to help prepare for specific Desert Rock activities, assist in operations during test events, and help ensure safe recovery operations following a nuclear detonation. The Desert Rock Radiological Safety Group and the Instructor Group were two of these elements. The tasks of the Radiological

Safety Group are discussed generally in chapter 2 and specifically in chapter 5 of this volume.

The Instructor Group prepared and conducted orientation programs for observers and maneuver troops. Before shot-day, this group presented a basic orientation course on nuclear weapons effects, personal protection, and shot-day procedures. During the rehearsal of shot-day exercises, instructors took personnel on tours of the equipment display areas. On shot-day, participants arrived at the trenches about 90 minutes before the detonation. Instructors then began their orientation over the loudspeakers. After the shot, the instructors led maneuver troops and observers through the display area and discussed the effects of the detonation (101; 102; 108).

Other support personnel entering the forward area were from the following units:

- Camp Desert Rock Signal Detachment
- Medical Detachment, Sixth Army
- 23rd Transportation Truck Company
- 31st Transportation Truck Company
- Company A, 505th Military Police Battalion
- Shore Battalion, 369th Engineer Amphibious Support Regiment.

These units usually entered the forward area only when large numbers of exercise troops were present, as at Shots CHARLIE, DOG, FOX, and GEORGE (101-103; 108).

The Camp Desert Rock Signal Detachment installed radio and wire communications systems, including a public address system, in each main trench area. On shot-day, participants operated two mobile public address systems consisting of trucks with loudspeakers. After the shot, they moved the system into the display area, where the Instructor Group used the loudspeakers to make presentations (101-103; 108).

Medical personnel present at Camp Desert Rock for Operation TUMBLER-SNAPPER were from the Sixth Army. Operations orders specified that, during the events, a medical detachment would move to the forward area and establish an aid station in a parking area. In addition to these medical personnel, the Camp Desert Rock Surgeon was in the forward area on shot-day and remained at the forward command post throughout the exercise. The units that participated in the maneuvers sometimes provided their own medical support (101-103; 108).

The 23rd Transportation Truck Company and the 31st Transportation Truck Company transported exercise troops from Camp Desert Rock to the trench area. They then moved the vehicles to a parking area farther to the rear. After the detonation and postshot activities, the vehicles were returned to the troop loading areas to transport the exercise troops back to Camp Desert Rock (101; 102; 108).

Company A, 505th Military Police Battalion, controlled the movement of Exercise Desert Rock vehicles in the forward area. Some of the military police were posted at entrances to the shot area, while others accompanied the units moving from Camp Desert Rock to the trench area. After the exercise troops had been taken to the trench location, the military police went to the parking area. After the detonation, they returned to posts at the road junctions to direct traffic from the trench area along the return route to Camp Desert Rock (101; 102; 108).

Another support element participating in the forward area was the 369th Engineer Amphibious Support Regiment. Members of this regiment customarily entered the forward area before a shot to construct trenches and equipment displays and after a shot to inspect and retrieve display items. Regiment personnel also participated as maneuver troops at Shot GEORGE (101; 102; 108).

Desert Rock IV Exercise Troops

About 7,350 Department of Defense personnel participated in TUMBLER-SNAPPER as Desert Rock IV exercise troops. These exercise troops represented each of the armed services. Unlike the support troops, the exercise troops were stationed at Camp Desert Rock for short periods ranging from several days to about two weeks (108).

Exercise Desert Rock IV consisted of two programs:

- Troop observation and indoctrination to acquaint military and civilian DOD personnel with the effects of nuclear detonations
- Tactical troop maneuvers to train participants in the use of nuclear weapons and to demonstrate the effects of nuclear detonations.

Table 3-1 indicates the estimated number of DOD participants in each activity at each shot.

The remainder of this chapter summarizes the Desert Rock IV programs as they were conducted during Operation TUMBLER-SNAPPER. Detailed descriptions of specific projects performed at each test of the series are presented in the TUMBLER-SNAPPER multi-shot volumes.

3.1 TROOP OBSERVER PROGRAM AT EXERCISE DESERT ROCK IV

The purpose of the observer program was to familiarize members of the armed services with the characteristic effects of nuclear detonations. Participants witnessed a nuclear event in the forward area of the Nevada Proving Ground and toured a display of ordnance materiel and military equipment arrayed in the vicinity of ground zero before and after the nuclear detonation.

Table 3-1: EXERCISE DESERT ROCK IV, ESTIMATED NUMBER OF PARTICIPANTS AT OPERATION TUMBLER-SNAPPER, BY PROGRAM

Program	Participating Service	ABLE	BAKER	CHARLIE	DOG	EASY	FOX	GEORGE	HOW
Observers	Army	0	0	300	0	0	950	500	0
	Army (Camp Desert Rock)	15	10	*	*	1,000	*	*	0
	Navy	0	0	0	300†	0	0	0	0
	USMC	0	0	0	50†	0	0	0	0
	Air Force	0	0	235	0	0	0	0	0
	Unknown	0	0	0	0	0	500**	0	0
Tactical Troop Maneuvers	Army	0	0	1,300	0	0	0	0	0
	Army (Camp Desert Rock)	0	0	*	0	0	0	1,300	0
	USMC	0	0	0	1,950	0	0	0	0
	Air Force	0	0	375	0	0	0	0	0
	Navy	0	0	0	0	0	0	0	0

* Unknown

† A combined total of 350 Marine Corps and Navy personnel has been documented; the breakdown by individual service is an estimate.

** These observers were from the continental armies and service schools.

A formal troop observer program was conducted at four of the eight TUMBLER-SNAPPER tests: Shots CHARLIE, DOG, FOX, and GEORGE. A few members of the Exercise Director's staff observed Shots ABLE and BAKER. The observers at Shot EASY were support personnel assigned to Camp Desert Rock.

The observer activities involved two groups, official observers and Camp Desert Rock observers. Official observers were usually military personnel selected from all services and from military bases throughout the United States. These personnel participated solely as observers and received the routine preshot briefings and orientation presented by the Camp Desert Rock staff. Most of the Camp Desert Rock observers were assigned to Desert Rock support units. They went to the forward area either to see a shot or to support the exercises. The size of this group of observers at any nuclear event varied with the participation of other observers and with troop maneuver activities. Some Camp Desert Rock support troops may have observed more than one nuclear test (18; 101-103; 108).

Throughout Operation TUMBLER-SNAPPER, observer activities were similar from one shot to the next. The armed services were invited to send observers to the nuclear tests. Each service was informed of the dates when observers should report for the shot, as well as the records and equipment they should bring to Camp Desert Rock. After arrival at Camp Desert Rock, both official and Camp Desert Rock observers participated in a standard set of activities, beginning with preshot classroom instruction conducted by the Instructor Group. Topics included basic nuclear theory, the characteristics and effects of nuclear weapons, protective measures to take during a nuclear attack, the medical effects of radiation, results of past exercises, and a plan of operations for the upcoming shot. The preshot orientation lectures were given over a period of several days. For those observers unable to arrive at Camp Desert Rock in time for this

instruction, a one-hour orientation was conducted the evening before the shot (101-103; 108).

In addition to the preshot classroom instruction, the Instructor Group conducted a rehearsal of shot-day activities. This rehearsal involved a visit to the trenches that the observers would occupy on shot-day, a practice of the countdown and activities scheduled for the detonation, and a tour of the display area. In some instances, the observers toured the display area of a previous nuclear test to see the postshot effects. Figure 3-1 shows the TUMBLER-SNAPPER trench and equipment display areas (101; 102; 108; 138).

About 90 minutes before the scheduled shot, observers arrived at the trench area by truck or bus convoy. The two observer groups were generally kept together and occupied the same trenches. In the trench area, observers were told what to expect and were briefed on safety procedures. They then entered the trenches, where they crouched for the final countdown and the shot (101; 102; 108). Figure 3-2 shows observers filing into the trenches before the detonation of CHARLIE, on 22 April 1952 (9). After the shot, the Desert Rock Control Group escorted the observers on a tour of the equipment display area to examine the effects of the detonation on equipment, fortifications, and shelters. Upon completing their tour, the observers returned to Camp Desert Rock by convoy (61; 101; 102; 108).

3.2 TACTICAL TROOP MANEUVERS PROGRAM AT EXERCISE DESERT ROCK IV

The troop maneuvers program at Exercise Desert Rock IV was designed to train participants in the tactical use of nuclear weapons and to teach participants about the effects of nuclear weapons on equipment, fortifications, and shelters. An important aspect of the program was to determine whether standard ground tactical movements could be employed under the radiological conditions resulting from the use of nuclear weapons.

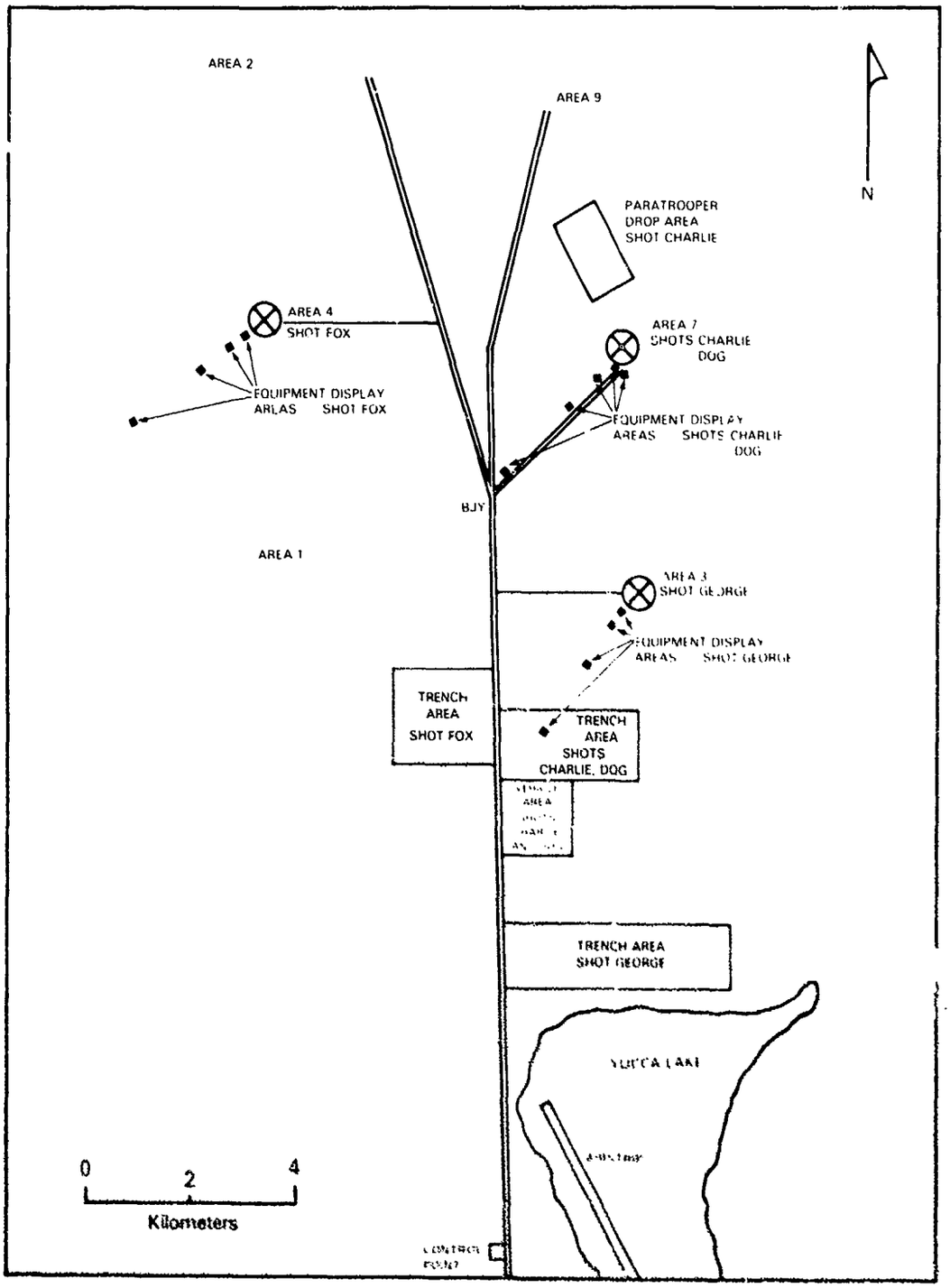

Figure 3-1: EXERCISE DESERT ROCK IV TRENCH AND DISPLAY AREAS, NEVADA PROVING GROUND, OPERATION TUMBLER-SNAPPER

Figure 3-2: OBSERVERS FILING INTO TRENCHES BEFORE THE DETONATION OF SHOT CHARLIE, 22 APRIL 1952

The troop maneuvers were conducted according to the following scenario. An aggressor with overwhelming forces had invaded the western United States, pushing friendly forces into retreat. The aggressor then established a line of strong defensive positions that resisted breakthrough by friendly forces. In order to gain the offensive and penetrate enemy lines, friendly forces planned a counterattack with nuclear weapons. A series of nuclear shots would be directed behind enemy lines in preparation for the attack. The actual nuclear detonation was to represent one of these shots, and the maneuver troops represented one element of the attacking friendly forces (58; 106; 108).

Units from the Army, the Marine Corps, and the Air Force traveled to the NPG specifically to participate in the maneuvers. At Camp Desert Rock, members of the military units were organized into composite Battalion Combat Teams (BCTs). BCT activities involved three phases:

- Observation of the nuclear blast
- Conduct of the tactical maneuver
- Tour of the display area.

Several hours before the shot, the BCTs traveled to the forward area by truck and bus convoy with participants in the troop observer program. After the preshot orientation, they entered trenches and foxholes, located as close as 6,400 meters to ground zero, to watch the detonation (101; 102; 108).

Following the detonation, the BCTs left the trenches to attack the exercise objective. Figure 3-3 shows maneuver troops leaving the trench area and beginning their advance. Radiological survey teams preceded the troops to determine the limits of safe advance. Radiological safety monitors also accompanied the troops as they moved toward their objective. After reaching their objective, or approaching as close as radiological safety standards would permit, the maneuver troops toured the equipment

Figure 3-3: MANEUVER TROOPS LEAVING FOXHOLES AND TRENCHES AND BEGINNING THE ADVANCE TOWARD THEIR OBJECTIVE

display area under the direction of the Desert Rock Instructor Group. They then boarded trucks and returned to Camp Desert Rock (101-103; 108).

Associated with the troop maneuvers at TUMBLER-SNAPPER was a study of the psychological reactions of troops participating in the maneuvers. The Human Resources Research Office (HumRRO), a civilian agency under contract to the Department of the Army, and the Operations Research Office (ORO) performed the study at Shots CHARLIE, FOX, and GEORGE. A similar study had been performed during Desert Rock I at Operation BUSTER-JANGLE in 1951. The agencies were particularly interested in observing troop behavior in the trench area immediately before and after the detonation and measuring the changes in troop attitudes about nuclear weapons before and after participation in the indoctrination exercises and the Desert Rock maneuvers. The data collected by HumRRO and ORO assisted the Army in determining the expected performances of troops involved in nuclear warfare (44; 61; 101-103; 108; 110; 162).

CHAPTER 4

DEPARTMENT OF DEFENSE PARTICIPATION IN JOINT AEC-DOD ORGANIZATION PROGRAMS AT OPERATION TUMBLER-SNAPPER

During Operation TUMBLER-SNAPPER, the joint AEC-DOD organization coordinated separate programs of scientific research, including scientific and diagnostic tests of the nuclear devices and tests of military effects of the nuclear detonations. Air support, also coordinated by the joint organization, was provided to these programs as needed. In most cases, the individual projects conducted under each program required relatively few personnel. Only about 750 of the DOD participants in TUMBLER-SNAPPER were part of the joint organization. Although their numbers were small compared to the number of Desert Rock personnel, the joint organization participants often repeated their tasks throughout the entire operation. The Desert Rock IV exercise troops, on the other hand, usually participated in only one or two nuclear test events.

This chapter describes the joint AEC-DOD activities, beginning with the scientific and diagnostic experiments conducted by two test groups:

- AFSWP Test Command Military Effects Test Group
- Los Alamos Scientific Laboratory Weapons Development Test Group.

Composed of scientists and technicians from various military and civilian laboratories, support contractors, and the armed services, the test groups developed and conducted field experiments to gather data before, during, and after the nuclear detonations.

Of the two test groups at Operation TUMBLER-SNAPPER, the Military Effects Test Group involved more DOD participants. A

part of the Department of Defense, this test group was from Test Command, Armed Forces Special Weapons Project, in Albuquerque, New Mexico. The group consisted of personnel from the Army, Navy, and Air Force. The mission of the Military Effects Test Group was to measure weapons effects characteristics. The findings were used to improve the U.S. nuclear arsenal and expand the techniques and strategies for using that arsenal. During Operation TUMBLER-SNAPPER, the Military Effects Test Group sponsored eight programs that included 44 separate projects (8; 119; 133; 138; 148).

The Weapons Development Test Group, from the Los Alamos Scientific Laboratory, performed diagnostic tests to characterize the phenomena produced by nuclear devices. The data from these experiments were used to improve nuclear devices, to develop new types of devices, and to test weapons before they entered the nuclear stockpile (8; 119; 133; 134; 138; 148).

Throughout Operation TUMBLER-SNAPPER, numbers were used to identify the sponsors of the technical programs and experiments performed by the test groups (8; 134; 138):

- Programs 1 through 9 were conducted by the Military Effects Test Group
- Programs 10 through 20 were conducted by the Weapons Development Test Group.

The final section of this chapter describes the air support and services provided by the Air Force Special Weapons Center. Based at Kirtland AFB, AFSWC supported the Test Manager and the test groups by supplying crews and aircraft for airdrop delivery missions, cloud-sampling and cloud-tracking missions, aerial surveys of the terrain, and other air missions as requested. The Air Operations Center, located at the AEC Control Point in Yucca Pass, exercised operational control over all aircraft flying over and near the Nevada Proving Ground (8; 10; 17; 82; 88).

4.1 MILITARY EFFECTS TEST GROUP PROGRAMS

The AFSWP Military Effects Test Group was responsible for conducting the weapons effects experiments for each detonation. Data from these experiments were used to provide a better understanding of the effects of nuclear weapons for both offensive and defensive military uses (8; 119; 134; 138; 148).

As figure 4-1 indicates, the Military Effects Test Group conducted eight programs during TUMBLER-SNAPPER (138). The Director of the Military Effects Test Group coordinated program activities. Each program was managed by a program director, who was responsible to the Director of the Military Effects Test Group. The programs were divided into several projects, each headed by a project officer (134; 138).

The Military Effects Test Group experiments were designed to attain the following DOD objectives (134; 138; 148):

- To develop the vehicles for deploying the nuclear devices
- To design military equipment able to withstand the effects of a nuclear detonation
- To develop procedures for the use of nuclear weapons
- To determine the military requirements for future nuclear weapons designs.

The Military Effects Test Group experiments were divided into three categories (138; 148):

- Basic measurements of the output characteristics of nuclear devices, such as blast, thermal, and radiation measurements
- Tests to determine blast, thermal, and radiation effects on experimental animals, structures, equipment, and material
- Operational tests to develop and evaluate techniques and equipment unique to nuclear warfare.

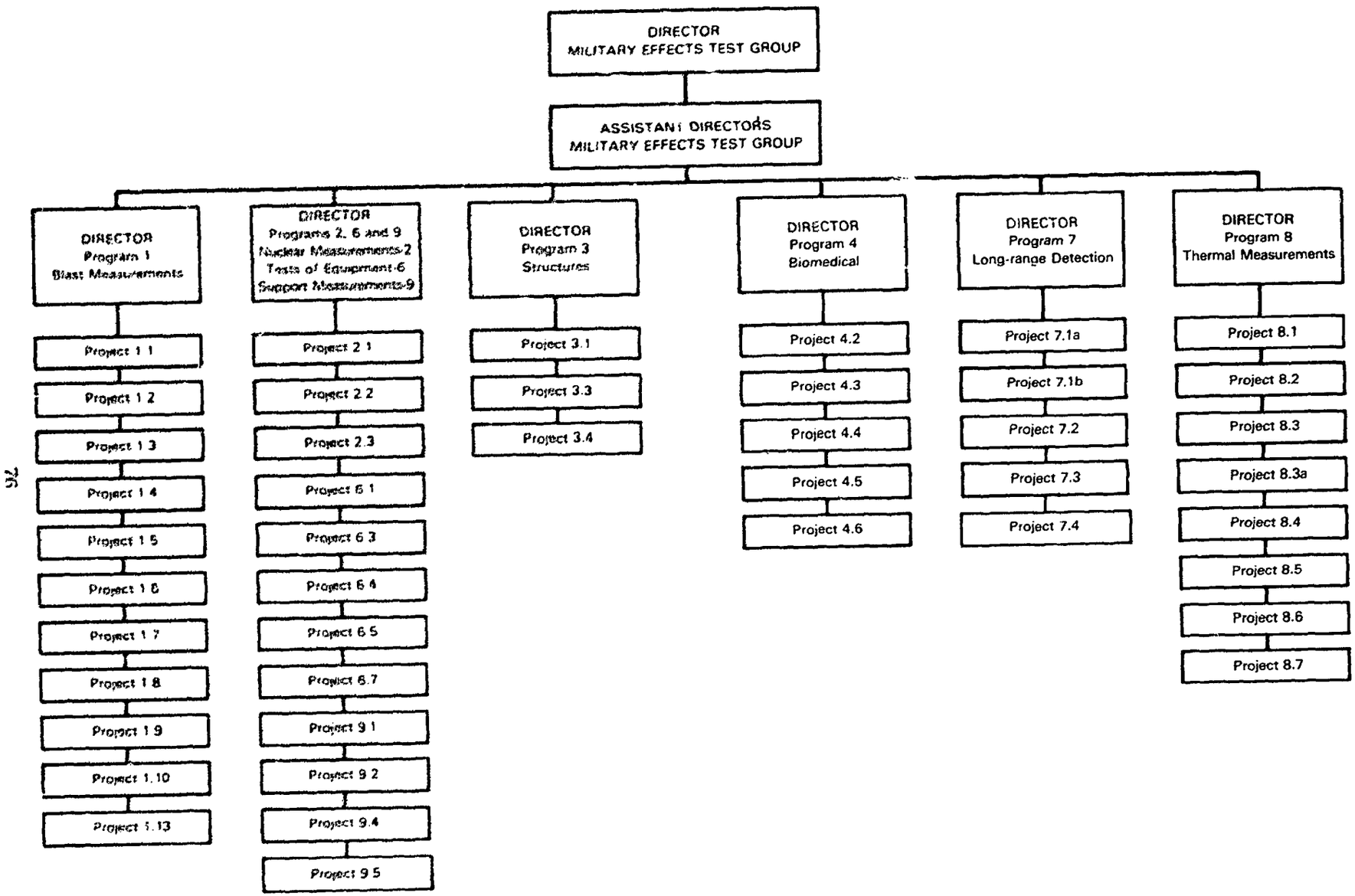

Figure 4-1: MILITARY EFFECTS TEST GROUP ORGANIZATION

Programs sponsored by the test group during TUMBLER-SNAPPER were:

- Program 1, Blast Measurements
- Program 2, Nuclear Measurements and Effects
- Program 3, Structures
- Program 4, Biomedical
- Program 6, Test of Equipment and Operations
- Program 7, Long Range Detection
- Program 8, Thermal Measurements and Effects
- Program 9, Supporting Measurements.

Program 5, which was to have involved Desert Rock technical experiments, was canceled before TUMBLER-SNAPPER began (119; 134; 138; 148).

Various military and civilian DOD laboratories and contractors fielded projects under these eight programs. Table 4-1 lists the programs and projects conducted at each shot. This table is an index to project descriptions in this chapter and in the TUMBLER-SNAPPER multi-shot volumes. In estimating the number of DOD personnel involved, it was assumed that the same personnel participated at each shot of the series and that the same personnel performed both preshot and postshot activities.

This section describes the projects' objectives and general procedures. The multi-shot volumes contain more detailed information regarding the number of personnel involved at each shot, their distances from ground zero, and their activities at a particular shot.

4.1.1 Program 1: Blast Measurements

Program 1, Blast Measurements, was designed to measure and analyze in detail the blast wave phenomena associated with

Table 4-1: MILITARY EFFECTS TEST GROUP PROGRAMS INDICATING PARTICIPATION BY SHOT

Program	ABLE	BAKER	CHARLIE	DOG	EASY	FOX	GEORGE	HOW	Estimated DOD Personnel
Program 1. Blast Measurements	1.2 1.3 1.4 1.5 1.6 1.7 1.9	1.2 1.3 1.4 1.5 1.6 1.7 1.9 1.13	1.2 1.3 1.5 1.6 1.7 1.9 1.13	1.2 1.3 1.4 1.5 1.6 1.7 1.9 1.13	1.1	1.4		1.1	66 13 7 3 8 4 13 3 14
Program 2. Nuclear Measurements and Effects	2.1	2.1	2.1 2.3	2.1 2.3	2.1 2.2	2.1 2.2	2.1 2.2	2.1 2.2 2.3	5 * 4
Program 3. Structures	3.1	3.1 3.3 3.4	3.1 3.3 3.4	3.1 3.3 3.4					66 15 14
Program 4. Biomedical			4.2 4.3 4.4 4.5 4.6	4.2 4.3 4.4 4.5 4.6	4.2 4.4			4.2 4.3 4.4	6 19 7 27 9
Program 5. Desert Rock			†	†		†	†		
Program 6. Test of Equipment and Operations	6.1 6.4	6.1 6.4	6.1 6.4	6.1 6.4 6.5	6.1 6.3 6.4 6.5	6.1 6.3 6.4 6.5 6.7	6.1 6.3 6.5 6.7	6.1 6.5 6.7	16 * * 5 *
Program 7. Long Range Detection	7.2 7.3	7.1b 7.2 7.3 7.4	7.1a 7.1b 7.2 7.3 7.4	7.1a 7.1b 7.2 7.3 7.4	7.1a 7.1b 7.2 7.3 7.4	7.1a 7.1b 7.2 7.3 7.4	7.1a 7.1b 7.2 7.3 7.4	7.1a 7.1b 7.2 7.3 7.4	* 48 * 135 4
Program 8. Thermal Measurements and Effects	8.2 8.3 8.6	8.2 8.3 8.4 8.6	8.1 8.2 8.3 8.3a 8.4 8.5 8.6	8.1 8.2 8.3 8.4 8.5 8.6		8.7	8.7	8.7	7 15 20 * 7 11 19 *
Program 9. Supporting Measurements	9.1 9.2 9.4	9.1 9.2 9.4 9.5	9.1 9.2 9.4 9.5	9.1 9.2 9.4 9.5	9.1 9.2 9.4 9.5	9.1 9.2 9.4 9.5	9.1 9.2 9.4 9.5	9.1 9.2 9.4	* 64 * *

*Unknown.

†Plans for scientific experiments were cancelled. Only troop training activities were conducted, as discussed in chapter 7 of this volume.

airburst nuclear devices. The program, which was the essential part of the TUMBLER phase of the test series, consisted of the 11 projects listed in table 4-2. Of these experiments, only Projects 1.1, 1.4, and 1.8 were part of the SNAPPER phase. The blast data obtained from Program 1 were used to interpret test results from the SNAPPER experiments (20; 138; 148).

Project 1.1, Measurement of Free-air Atomic Blast Pressures, was conducted at Shots EASY and HOW by the Air Force Cambridge Research Center and the Rome Air Development Center. The objective was to measure the pressures produced by a nuclear detonation over a wide range of altitudes and distances. This project was a continuation of similar experiments conducted during Operation BUSTER-JANGLE to field-test theoretical calculations.

Guided by radar, two B-29 aircraft from the Rome Air Development Center each dropped eight parachute-borne canisters carrying instruments that measured altitude and pressure. On the ground, a tracking system monitored the location of the canisters, and a telemetry station recorded data from the instruments. Data gained from the project showed that theoretical calculations gave a fairly accurate indication of free-air blast pressures (82; 94; 134; 138; 148; 152).

Project 1.2, Air Pressure versus Time, was conducted by the Stanford Research Institute at Shots ABLE, BAKER, CHARLIE, and DOG. The objective was to collect data on the airblast produced by airdropped nuclear devices. Measurements were taken to determine the optimum burst height for producing a maximum area of pressure at ground level. The experiment was an attempt to resolve differences in predicted and observed ground-level pressures found during Operation BUSTER-JANGLE. The results from the project at TUMBLER-SNAPPER were consistent enough to enable preparation of a chart showing height of burst versus pressure.

Table 4-2: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 1 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
1.1	Measurement of Free-air Atomic Blast Pressures	To measure pressures produced by nuclear detonations over various altitudes and distances	EASY, HOW	Air Force Cambridge Research Center; Rome Air Development Center
1.2	Air Pressure versus Time	To determine the optimum burst height for producing a maximum pressure area at ground level	ABLE, BAKER, CHARLIE, DOG	Stanford Research Institute
1.3 and 1.5	Free-air and Ground-level Pressure Measurements	To measure pressures produced by nuclear detonations at ground level and in free air	ABLE, BAKER, CHARLIE, DOG	Naval Ordnance Laboratory
1.4	Air Blast Measurements	To determine the shape and peak pressure of the shock wave generated near the ground from a nuclear detonation high in the air; to determine blast arrival time using radiotelemetric systems	ABLE, BAKER, DOG, FOX	Ballistic Research Laboratories
1.6	Ground Acceleration Measurements	To measure ground shock resulting from a nuclear detonation by use of gauges and other instruments	ABLE, BAKER, CHARLIE, DOG	Ballistic Research Laboratories
1.7	Earth Acceleration versus Time	To measure the proportion of blast energy absorbed from the air by the earth	ABLE, BAKER, CHARLIE, DOG	Stanford Research Institute
1.8	Geological Survey of the AEC Area, Nye County, Nevada	To study the geologic and topographic features of the Nevada Proving Ground	None	AFSWP, Coast and Geodetic Survey
1.9	Pre shock Dust	To determine the concentration and size distribution of the pre-shock dust generated before arrival of the shock wave by thermal radiation resulting from a nuclear detonation	ABLE, BAKER, CHARLIE, DOG	Army Chemical Center
1.10	Pressure distance Height Study of 250 pound TNT Spheres	To obtain data on the variation of pressure with height of burst using 250-pound spherical TNT charges	None	Sandia Corporation
1.13	Measurement of Air Blast Pressure versus Time	To provide blast pressure data for Program 3 agencies, especially those in Project 3.1, Vulnerability of Parked Aircraft to Atomic Bombs	BAKER, CHARLIE, DOG	David Taylor Model Basin

Data from this chart were used in preparing Technical Manual (TM)23-200, Capabilities of Atomic Weapons, issued in October 1952. The Army used this manual as a source of information about nuclear weapons effects (134; 145).

Projects 1.3 and 1.5, Free-air and Ground-level Pressure Measurements, were conducted as one project by the Naval Ordnance Laboratory at Shots ABLE, BAKER, CHARLIE, and DOG. The projects, continuations of similar studies at Operations SANDSTONE, GREENHOUSE, and BUSTER-JANGLE, were designed to measure pressures produced by nuclear detonations at ground level and in free air. Project 1.3 personnel used pressure gauges positioned around ground zero to take measurements, while Project 1.5 participants measured pressures in free air by photographing smoke rocket trails (35; 134).

Project 1.4, Air Blast Measurements, was conducted at Shots ABLE, BAKER, DOG, and FOX by the Ballistic Research Laboratories. The objective at ABLE, BAKER, and DOG was to determine the shape and peak pressure of the shock wave generated near the ground from a nuclear device detonated high in the air. The objective at FOX was to use radiotelemetric systems as a means of determining blast arrival time (40; 134).

Project 1.6, Ground Acceleration Measurements, was performed at Shots ABLE, BAKER, CHARLIE, and DOG by the Ballistic Research Laboratories. The objective was to obtain ground acceleration measurements for the four TUMBLER-SNAPPER airbursts. The experiment was a continuation of a similar project performed at Operations BUSTER-JANGLE and GREENHOUSE, which used gauges and other instruments to measure ground shock resulting from a nuclear detonation. Figure 4-2 shows Project 1.6 personnel in postshot recovery operations (9; 85; 134).

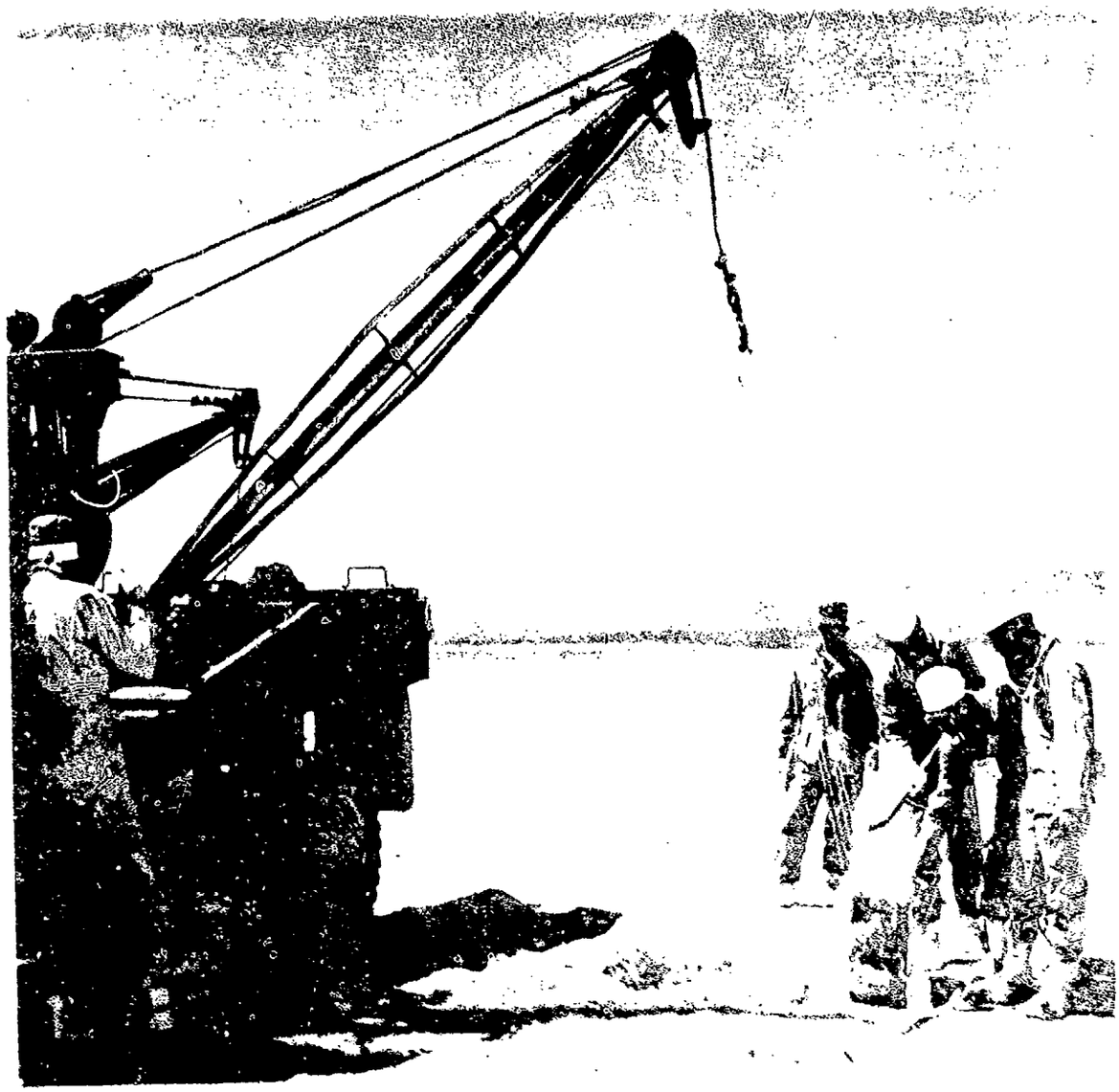

Figure 4-2: PROJECT 1.6 PERSONNEL REMOVE ACCELEROMETERS USED TO MEASURE GROUND SHOCK

Project 1.7, Earth Acceleration versus Time, was conducted by the Stanford Research Institute at Shots ABLE, BAKER, CHARLIE, and DOG. The objective was to measure the proportion of blast energy absorbed from the air by the earth. Analysis of data gathered with earth accelerometers and pressure gauges indicated that, for airbursts over surfaces similar to the test site, earth absorption of air blast energy is negligible (134; 146).

Project 1.8, Geological Survey of the Atomic Energy Commission Area, Nye County, Nevada, was conducted during Operation TUMBLER-SNAPPER by AFSWP and the Coast and Geodetic Survey. The objective was to study the geology and topography of the Nevada Proving Ground. Data obtained from the project were to be used in determining the effects of geological structure on the propagation of the blast wave.

Project personnel conducted limited field work on this survey in the fall of 1951, during Operation BUSTER-JANGLE. In February 1952, AFSWP began detailed geologic field mapping and continued this activity through Operation TUMBLER-SNAPPER, until mid-August 1952. To provide an accurate geologic picture of Yucca Flat and Frenchman Flat, project personnel studied the general composition of the valley, the configuration of the valley floor, and the faults and temperatures of the valley at different depths. In addition, they took aerial photographs of the test area (111).

Project 1.9, Pre-shock Dust, was conducted at Shots ABLE, BAKER, CHARLIE, and DOG by the Chemical and Radiological Laboratories of the Army Chemical Center. The objective was to determine the concentration and the size distribution of the dust generated before the arrival of the shock wave by thermal radiation resulting from a nuclear detonation. Instruments, including cascade impactors and filter samplers, were used to collect dust particles generated during the brief interval

between the detonation and the arrival of the blast wave. AFSWC transported dust samples to the Army Chemical Center for analysis, as described in section 4.3 of this chapter (46; 134).

Project 1.10, Pressure-distance Height Study of 250-pound TNT Spheres, was conducted by the Sandia Corporation before and after Operation TUMBLER-SNAPPER. The objective was to obtain data on the variation of pressure with height of burst using 250-pound spherical TNT charges. Data from the detonations preceding TUMBLER-SNAPPER were used to predict the pressures that would result from Shots ABLE, BAKER, CHARLIE, and DOG. Some of the TNT detonations conducted before the series were onsite, but all detonations after TUMBLER-SNAPPER were in Coyote Canyon, New Mexico (149).

Project 1.13, Measurement of Air Blast Pressure versus Time, was conducted at Shots BAKER, CHARLIE, and DOG. The experiment was conducted by personnel from the David Taylor Model Basin. The project was designed to provide blast pressure data for Program 3, particularly Project 3.1, Vulnerability of Parked Aircraft to Atomic Bombs, discussed in section 4.1.3 of this chapter. Measurements were to be correlated with damage to aircraft parked at various distances from ground zero. The David Taylor Model Basin consulted with Project 3.1 personnel regarding their requirements for the location of pressure gauges in the areas of the parked aircraft (67; 134; 147).

4.1.2 Program 2: Nuclear Measurements and Effects

Program 2, Nuclear Measurements and Effects, was designed to characterize gamma and neutron radiation from a nuclear detonation. Table 4-3 lists the Program 2 projects conducted during Operation TUMBLER-SNAPPER, including the shots at which the project was performed and the participating organizations (138).

Table 4-3: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 2 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participating Agency
2.1	Total Gamma Exposure versus Distance	To measure gamma radiation exposure as a function of distance	All	Signal Corps Engineering Laboratories
2.2	Gamma Ray Energy Spectrum of Residual Contamination	To determine relative dosage contribution of various gamma-radiation energies in contaminated areas after a nuclear detonation	EASY, FOX, GEORGE, HOW	Signal Corps Engineering Laboratories
2.3	Neutron Flux and Energy Measurements	To measure neutron flux and to evaluate neutron dosimetry techniques	CHARLIE, DOG, HOW	Naval Research Laboratory

Project 2.1, Total Gamma Exposure versus Distance, was performed at all shots in the series by the Signal Corps Engineering Laboratories. The objective was to measure gamma radiation exposure as a function of distance along a radial line from the point of detonation. Project personnel placed National Bureau of Standards film packets up to 1,000 meters from ground zero for the low-yield shots, ABLE and BAKER, and up to 2,750 meters from the point of detonation for the other shots, which had higher yields. Project personnel also made additional exposure measurements for Projects 1.13, 3.1, and 6.1; the Office, Chief of Army Field Forces; and the Marine Corps (116; 134).

Project 2.2, Gamma Ray Energy Spectrum of Residual Contamination, was conducted at Shots EASY, FOX, GEORGE, and HOW by the Signal Corps Engineering Laboratories. The objective was to determine the relative dose contribution of various gamma radiation energies in radiation areas following a nuclear detonation. To perform this experiment, project personnel used radiation survey meters modified to shield portions of the gamma ray energy spectrum. The information gained was of military

importance for determining the radiation dose rates in test areas and for designing survey instruments.

Before each shot, project personnel calibrated five AN/PDR-T1B radiac instruments. After the Test Manager announced recovery hour, participants placed the instruments on wooden tripods facing ground zero in the shot area. After taking readings with the instruments, they moved the equipment to other locations in the radiation field to determine any dependence of the gamma ray spectrum on distance from the point of detonation. At the conclusion of the field work, participants dismantled equipment and returned to Camp Mercury to analyze data. They took measurements in the shot area again on the first and second days after the detonation (134; 159).

Project 2.3, Neutron Flux and Energy Measurements, was performed at Shots CHARLIE, DOG, and HOW by the Naval Research Laboratory. The project was designed to measure neutron flux and to evaluate neutron dosimetry techniques. Before each shot, project personnel placed gold, sulphur, and tantalum neutron detectors 180 to 1,830 meters from the intended ground zero. After the detectors were recovered, they were sent to laboratories for analysis (92; 134).

4.1.3 Program 3: Structures

Program 3, Structures, investigated blast effects on such objects as aircraft, land mines, and trees. Table 4-4 lists the projects conducted under Program 3 during Operation TUMBLER-SNAPPER and states the purpose of each project, the shots at which the project was conducted, and the fielding agency (138).

Project 3.1, Vulnerability of Parked Aircraft to Atomic Bombs, was performed at Shots ABLE, BAKER, CHARLIE, and DOG by the Wright Air Development Center of Dayton, Ohio, and by

personnel from LASL and the Naval Radiological Defense Laboratory. The objective was to determine the effects of an airburst nuclear detonation on parked aircraft. The experiment was coordinated with Project 1.13, which provided airblast pressure data to project personnel (147).

Table 4-4: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 3 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
3.1	Vulnerability of Parked Aircraft to Atomic Bombs	To determine the effects of an airburst nuclear detonation on aircraft parked in the surrounding area	ABLE, BAKER, CHARLIE, DOG	Wright Air Development Center; LASL; Naval Radiological Defense Laboratory
3.3	Blast Damage to Trees Isolated Conifers	To predict the effects of a nuclear blast on isolated coniferous trees	BAKER, CHARLIE, DOG	Forest Service Department of Agriculture
3.4	Minefield Clearance	To evaluate the practicality of using nuclear weapons to clear minefields	BAKER CHARLIE DOG	Engineer Research and Development Laboratories

Participants at Shot ABLE tested only the photographic equipment to be used for the project at BAKER, CHARLIE, and DOG. Twenty-eight aircraft, including 16 F-47s, seven B-17s, two F-86s, one F-90, one B-45, and one B-29, were positioned at various ranges from ground zero at Shots BAKER, CHARLIE, and DOG. To compare the protection afforded aircraft by various defense structures, some of the aircraft were placed in revetments and behind walls, while others were in the open. The aircraft were instrumented to measure thermal, blast, and radiation effects (134; 147).

Project 3.3, Blast Damage to Trees--Isolated Conifers, was conducted at Shots BAKER, CHARLIE, and DOG by the Forest Service, Department of Agriculture. The project was part of a research program aimed at predicting the effects of a nuclear blast on

forests. This experiment was designed to measure motion and strain on isolated trees subjected to a nuclear detonation.

Before each shot, project personnel placed four trees and instruments to measure strain at each of four stations on the Forest Service Line in Area 7. Figure 4-3 shows participants positioning the trees. The stations were 1,520 to 6,100 meters from ground zero. The trees, approximately 50 feet high, were anchored in concrete.

After the shot, participants studied physical characteristics of the broken trees, such as the weight and moisture content of foliage and branchwood. Personnel from the Army Pictorial Service Division took motion pictures of the trees (50; 134).

Project 3.4, Minefield Clearance, was performed at Shots BAKER, CHARLIE, and DOG by the Engineer Research and Development Laboratories. The project, a study of the detonation of land mines by a nuclear blast, was a continuation of similar experiments conducted at Operation BUSTER-JANGLE to evaluate the practicality of using nuclear weapons to clear minefields.

Before Shot BAKER, project personnel laid a minefield with live fuses in Area 7. The minefield, which was 15 meters wide, extended approximately 90 to 1,830 meters from ground zero. Project personnel began recovery within 24 hours after each shot. In the process, they:

- Uncovered mines
- Removed pressure plates from mines
- Removed and replaced fuses
- Inspected and, if necessary, replaced damaged plates
- Reset plates and replaced dirt around the mines.

They then transported the damaged pressure plates and fuses to Camp Mercury for analysis (134; 143).

Figure 4-3: PROJECT 3.3 PERSONNEL INSTALL TREES ALONG THE FOREST SERVICE BLAST LINE IN AREA 7

4.1.4 Program 4: Biomedical

Program 4, Biomedical, consisted of five projects designed to characterize the biological effects of the blast, heat, and radiation resulting from a nuclear detonation. Table 4-5 presents information on these five projects (138).

Table 4-5: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 4 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
4.2	Biomedical Exposure Equipment	To evaluate equipment designed to measure blast, thermal, and radiation effects	CHARLIE, DOG, EASY, HOW	Naval Medical Research Institute
4.3	Biological Effectiveness of Neutron Radiation from Nuclear Weapons	To study the biological effects of neutron radiation on mice	CHARLIE, DOG, HOW	Naval Radiological Defense Laboratory
4.4	Gamma Depth Dose Measurement in Unit Density Material	To improve techniques used to evaluate biological effects of radiation on living tissue, particularly the human body	CHARLIE, DOG, EASY, HOW	Naval Medical Research Institute
4.5	Flash Blindness	To determine to what degree the flash of a nuclear detonation impairs night vision	CHARLIE, DOG	Air Force School of Aviation Medicine, Air Training Command, Brooke Army Medical Center, Strategic Air Command
4.6	Time Course of Thermal Radiation as Measured by Burns in Pigs	To study the production of skin burns in pigs	CHARLIE, DOG	Naval Medical Research Institute, University of Rochester Atomic Energy Project

Project 4.2, Biomedical Exposure Equipment, was conducted at Shots CHARLIE, DOG, EASY, and HOW by the Naval Medical Research Institute. The project evaluated equipment designed to measure blast, thermal, and radiation effects. To measure exposure to direct airblast, project personnel constructed wood models of dogs, which they instrumented with accelerometers and placed in cocktainers fitted with pressure recorders. Blast pressures were then correlated with movement. For thermal effects, project

personnel modified and instrumented exposure containers used during Operation GREENHOUSE. Swine were exposed in these containers, and the intensity of thermal radiation was correlated with the burns produced. To measure nuclear radiation effects, project personnel used film and glass dosimeters to measure variations in gamma exposure at different locations within multiple-compartment mouse cages (79; 134).

Project 4.3, Biological Effectiveness of Neutron Radiation from Nuclear Weapons, was conducted at Shots CHARLIE, DOG, and HOW by the Naval Radiological Defense Laboratory. The project was originally scheduled for Shots DOG, HOW, and the ninth TUMBLER-SNAPPER detonation. When it was decided that the series would not include the ninth test, the project was scheduled for CHARLIE, along with the other two shots. The objective was to study the biological effects of neutron radiation on mice.

Before each shot, project participants placed approximately 30 mice in cages at several field stations. The stations, shielded with lead, bismuth, or aluminum, were located at various distances from ground zero. Approximately three hours after each shot, project personnel retrieved the mice, which were taken to laboratories for pathological analysis (56; 134).

Project 4.4, Gamma Depth Dose Measurement in Unit Density Material, was performed at Shots CHARLIE, DOG, EASY, and HOW by the Naval Medical Research Institute. The experiment, which had been performed at Operations GREENHOUSE and HUSTLER-JANGLE, was designed to improve techniques used to evaluate biological effects of radiation on living tissue, particularly the human body. Project personnel conducted their experiment with lucite spheres approximating the density of human tissue.

To measure gamma doses, project participants placed dosimeters inside each sphere. Before each detonation, they placed

spheres approximately 1,000 to 1,740 meters from ground zero. After the declaration of recovery hour, they spent about one hour retrieving the spheres (57; 134).

Project 4.5, Flash Blindness, was conducted at Shots CHARLIE and DOG by the Air Force School of Aviation Medicine. Participating in the project were personnel from the Air Training Command, SAC, and the Brooke Army Medical Center. The objective was to determine to what degree the flash of a nuclear detonation impairs the night vision of personnel. The protection afforded by the use of high-density goggles was also evaluated.

The test subjects witnessed the detonation from a darkened trailer about 16 kilometers from the point of detonation, near the Control Point. Twelve portholes along the side of the trailer were fitted with shutters to expose the eyes of the subjects to the nuclear flash. During the exposure, half wore protective goggles, while the other half did not. Following the exposure, the subjects were required to read lighted instruments to determine how soon they could perform visual tasks (54; 59; 134; 157).

Project 4.6, Time Course of Thermal Radiation as Measured by Burns in Pigs, was conducted at Shots CHARLIE and DOG by the Naval Medical Research Institute and the University of Rochester Atomic Energy Project. The Naval Medical Research Institute provided test equipment, while the Atomic Energy Project supplied the animals and conducted the biological experiments. The project was designed to study the production of skin burns in pigs.

On the day before each detonation, project personnel weighed the pigs and inspected their skins. From six to three hours before the detonation, personnel transported the pigs to

stations, anesthetized them, and placed them in containers. Personnel then left the area. About two hours after the detonation, participants recovered the animals and transported them to a laboratory for evaluation of their burns (113; 134).

4.1.5 Program 5: Desert Rock

The Armed Forces Special Weapons Project originally scheduled Program 5, Desert Rock, for scientific experiments to be conducted in conjunction with Exercise Desert Rock IV. Plans for the scientific experiments were later canceled, but troop training activities were conducted at Shots CHARLIE, DOG, FOX, and GEORGE (138). These activities are discussed in chapter 3 of this volume.

4.1.6 Program 6: Test of Equipment and Operations

Program 6, Test of Equipment and Operations, tested procedures and equipment for potential use in nuclear warfare. The program evaluated:

- Military radiological equipment
- Decontamination procedures
- Indirect Bomb Damage Assessment (IBDA) techniques.

The five projects conducted as part of Program 6 are listed in table 4-6 (138).

Table 4-6: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 6 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
6.1	Evaluation of Military Radiac Equipment	To evaluate radiac survey and dose-alarm equipment, dosimeters, and instruments and techniques used for rapid aerial surveys	All	Bureau of Ships; Signal Corps Engineering Laboratories
6.3	Evaluation of a Filtration System for Pressurized Aircraft	To determine the adequacy of a system for filtering particulate airborne fission products from the cabin air supply of a B-29 aircraft	EASY, FOX, GEORGE	Army Chemical Center
6.4	Operational Tests of Radar and Photographic Techniques for IBDA	To evaluate the Indirect Bomb Damage Assessment System under development at the Wright Air Development Center	ABLE, BAKER, CHARLIE, DOG, EASY, FOX	Wright Air Development Center; Strategic Air Command
6.5	Decontamination of Aircraft	To investigate methods of reducing radiological hazards to maintenance and flight crews	DOG, EASY, FOX, GEORGE, HOW	Wright Air Development Center; Naval Radiological Defense Laboratory
6.7	Evaluation of Air Monitoring Instruments	To determine the adequacy of a Chemical Corps air sampler for radiological air monitoring	FOX, GEORGE, HOW	Army Chemical Center

Project 6.1, Evaluation of Military Radiac Equipment, was conducted at all TUMBLER-SNAPPER shots by the Bureau of Ships and the Signal Corps Engineering Laboratories. The objective was to evaluate radiac survey and dose-alarm equipment, dosimeters, and the instruments and techniques used for rapid aerial surveys. Project personnel supplied radiation survey instruments to test group participants.

Project personnel tested 14 different radiac instruments and decided that three instruments then in production, the AN/PDR-T1B, the AN/PDR-27, and the AN/PDR-18, would be adequate for field use if they underwent minor modifications.

In studying the techniques and instruments for the rapid aerial survey, project personnel used portable military radiac meters to conduct a survey from an LC-126 aircraft. The results of their study indicated that a fairly accurate rapid survey could be made with small aircraft and portable radiacs available to a field commander. Such a survey would enable a field commander to determine quickly the radiological conditions in a maneuver area (134; 151).

Project 6.3, Evaluation of a Filtration System for Pressurized Aircraft, was conducted at Shots EASY, FOX, and GEORGE by the Army Chemical Center. The objective was to determine the adequacy of a system for filtering particulate airborne fission products from the cabin air supply of B-29 aircraft. Levels of radioactivity in air samples taken before and after passage through the filtering unit were compared. The results indicated that the filter unit removed more than 99.9 percent of the airborne fission products from the air stream entering the unit. Provided by the 4925th Test Group (Atomic), the two B-29 aircraft participating in this project staged from Indian Springs AFB. After penetrating the cloud at altitudes ranging from 16,000 to 32,000 feet, the aircraft returned to base. The filter samples were then removed from the B-29s and transported by B-25 courier aircraft to the Army Chemical Center (82; 134; 137). Courier flights are discussed in chapter 4.3 of this volume, which describes AFSWC support missions at Operation TUMBLER-SNAPPER.

Project 6.4, Operational Tests of Radar and Photographic Techniques for IBDA, was conducted at Shots ABLE, BAKER, CHARLIE, DOG, EASY, and FOX by the Wright Air Development Center. The objective was to evaluate the Indirect Bomb Damage Assessment (IBDA) system under development at the Wright Air Development Center. Project 6.4 used, for the first time, all elements of the IBDA system, which was to provide data for the determination of ground zero, height of burst, and yield. The 509th

Bombardment Group of the Strategic Air Command provided three B-50D aircraft, which were instrumented by project personnel. These three aircraft either accompanied the B-50D drop aircraft or simulated the positions of drop and escort planes. Analysis of data indicated that yield, height of burst, and ground zero could be determined with sufficient accuracy to be useful (45; 82).

Project 6.5, Decontamination of Aircraft, was conducted at Shots DOG, EASY, FOX, GEORGE, and HOW by the Wright Air Development Center and by the Naval Radiological Defense Laboratory. The project was designed to investigate methods of reducing external and internal radiation exposures to maintenance and flight crews.

The project evaluated standard and experimental types of cleaning materials and equipment used to decontaminate aircraft. The study was also planned to determine the (134; 156):

- Effectiveness of various decontamination methods
- Relative amount of contamination adhering to oiled, polished, and clean aircraft surfaces
- Distribution of contamination on aircraft contaminated during a flight
- Relationship between aircraft contamination and cockpit exposure rate.

Project 6.7, Evaluation of Air Monitoring Instruments, was conducted at Shots FOX, GEORGE, and HOW by the Army Chemical Center. The test area of Shot EASY was also instrumented for the project, but wind conditions prevented recovery of the equipment in the established time. The objective was to determine the adequacy of a Chemical Corps air sampler for radiological monitoring.

Before each shot, project personnel placed six air samplers at each of four stations located at various directions and ranges

from ground zero. The stations were positioned in the expected areas of fallout. Changes in the actual fallout pattern, however, sometimes caused difficulties in obtaining meaningful results, as at Shot EASY. The results indicated that the Chemical Corps air sampler was not suitable for field use (93; 134).

4.1.7 Program 7: Long-range Detection

Program 7, Long-range Detection, was part of a continuing Air Force program to analyze detonation phenomena and to develop techniques for detecting nuclear detonations at long ranges. The program consisted of five projects, as listed in table 4-7 (138).

Table 4-7: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 7 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
7.1a	Electromagnetic Effects from Atomic Explosions	To study the electromagnetic pulses produced by nuclear detonations	CHARLIE, DOG, EASY, FOX, GEORGE, HOW	National Bureau of Standards; Air Force Cambridge Research Center; Air Weather Service; Geophysical Laboratory of UCLA
7.1b	Long Range Light Measurements	To gain additional information on the long-range detection of light produced by a nuclear detonation	BAKER, CHARLIE, DOG, EASY, FOX, GEORGE, HOW	EG&G; Headquarters, Air Force
7.2	Detection of Airborne Low frequency Sound from Atomic Explosions	To determine the accuracy of acoustic long range detection methods	All	Headquarters, Air Force Signal Corps Engineering Laboratories, National Bureau of Standards
7.3	Radiochemical and Physical Analyses of Atomic Bomb Debris	To analyze particulate and gaseous samples from the nuclear cloud	All	Headquarters, Air Force
7.4	Seismic Waves from A Bombs Detonated over a Desert Valley	To determine the effects of the NPG geological structure on the transmission of the seismic waves produced by a nuclear detonation	BAKER, CHARLIE, DOG, EASY, FOX, GEORGE, HOW	Air Force 1009th Special Weapons Squadron, Coast and Geodetic Survey

Project 7.1a, Electromagnetic Effects from Atomic Explosions, was conducted at Shots CHARLIE, DOG, EASY, FOX, GEORGE, and HOW by the:

- National Bureau of Standards
- Air Force Cambridge Research Center
- Air Weather Service
- Geophysical Laboratory of the University of California at Los Angeles.

The project, which continued similar experiments conducted at Operations CROSSROADS, SANDSTONE, RANGER, GREENHOUSE, and BUSTER-JANGLE, was designed to study the electromagnetic pulses produced by nuclear detonations. Data were evaluated to determine the location of distant nuclear detonations. The onsite stations were at Frenchman and Yucca Flats, and the offsite stations were in Colorado, Florida, Georgia, Massachusetts, New Mexico, Virginia, Bermuda, Germany, and Puerto Rico (135).

Project 7.1b, Long Range Light Measurements, was conducted entirely offsite at Shots BAKER, CHARLIE, DOG, EASY, FOX, GEORGE, and HOW by EG&G and Headquarters, Air Force. The objective was to gain additional information on the long-range detection of light produced by a nuclear detonation.

EG&G and Headquarters, Air Force, established light-detecting stations in Arizona, Idaho, Texas, and Washington. An estimated two EG&G employees and ten Air Force personnel from the Sacramento Air Materiel Area, McClellan AFB, operated each station from about six hours before to one hour after the detonation (80).

Project 7.2, Detection of Airborne Low-frequency Sound from Atomic Explosions, was sponsored at all TUMBLER-SNAPPER shots by Headquarters, Air Force, with assistance from the Signal Corps

Engineering Laboratories and the National Bureau of Standards. This project, conducted offsite, was part of a continuing program, initiated during Operations GREENHOUSE and BUSTER-JANGLE, to determine the accuracy of acoustic long-range detection methods. The Signal Corps Engineering Laboratories operated stations in Alaska, Hawaii, Kentucky, New Jersey, Texas, and Washington. The National Bureau of Standards operated a station in Washington, D.C.

Results from the project reinforced conclusions drawn from previous test series. The detection range of acoustical equipment depended upon yield of the detonation, atmospheric conditions, existing noise levels at each recording station, and the sensitivity of the sound-receiving equipment. Recommendations were made to continue similar tests during future test series (136).

Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, was conducted at all shots by Headquarters, Air Force. The project involved analysis of particulate and gaseous samples from the clouds formed by the detonations. Cloud sampling, performed by the 4925th Test Group (Atomic) of Kirtland AFB, is discussed in section 4.3, Air Force Support Missions at Operation TUMBLER-SNAPPER (82; 150).

Project 7.4, Seismic Waves from A-Bombs Detonated over a Desert Valley, was conducted at Shots BAKER, CHARLIE, DOG, EASY, FOX, GEORGE, and HOW by the Air Force 1009th Special Weapons Squadron and the Coast and Geodetic Survey. The objective was to determine the seismic properties of the geological structure of the test area following a nuclear detonation. Unmanned recording stations were located in Yucca and Frenchman Flats and at remote locations up to 700 kilometers offsite. The project confirmed results obtained at Operation BUSTER-JANGLE, that less than five

percent of the energy entering the ground as seismic waves is transmitted to remote locations (55).

4.1.8 Program 8: Thermal Measurements and Effects

Program 8, Thermal Measurements and Effects, investigated various aspects of thermal radiation and its effects on atmospheric transmissions, weather, forest fuels, and structures. This program, which was coordinated with Program 18, Thermal Radiation Measurements, included the eight projects shown in table 4-8 (138).

Project 8.1, Effects of Atomic Explosions on Forest Fuels, was performed at Shots CHARLIE and DOG by the Forest Service, Department of Agriculture. The experiment, which continued a similar study conducted during Operation BUSTER-JANGLE, was to determine the minimum thermal energies required to ignite common forest fuels, such as pine needles, hardwood leaves, grass, and rotten wood. Other objectives were to:

- Determine blast wave effect on the persistence of fires
- Provide field data for laboratory tests
- Provide information for possible offensive and defensive military operations in woodland areas and civilian defense activities in urban and rural areas.

Before each shot, project personnel arranged the forest fuels in trays located at various distances from ground zero. Personnel from the LASL graphic arts section then photographed the fuel beds. The Army Pictorial Service Division, Office of the Chief Signal Officer, installed three motion picture cameras which photographed the ignition and combustion of the fuel beds. After the Test Manager opened the area for recovery operations, LASL personnel again photographed the fuel beds. Project personnel then retrieved the materials for analysis (34; 134).

Table 4-8: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 8 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
8.1	Effects of Atomic Explosions on Forest Fuels	To determine the minimum thermal energies required to ignite common forest fuels	CHARLIE, DOG	Forest Service, Department of Agriculture
8.2	Air Temperatures in the Vicinity of a Nuclear Detonation	To determine the effect of a heated air layer on the blast wave	ABLE, BAKER, CHARLIE, DOG	Naval Radiological Defense Laboratory
8.3	Thermal Radiation from a Nuclear Detonation	To measure the total thermal radiation and the intensity-time relationship of the radiation as a function of distance from ground zero	ABLE, BAKER, CHARLIE, DOG	Naval Radiological Defense Laboratory
8.3a	Thermal Radiation Measurements Using Passive Indicators	To evaluate the field performance of passive heat-sensitive materials in measuring the total thermal radiation incident as a function of distance from ground zero	CHARLIE	Naval Material Laboratory
8.4	Atmospheric Transmission and Weather Measurements	To provide data on meteorological conditions for use in thermal radiation projects and to supplement information supplied by Project 9.2, Air Weather Service Participation	BAKER, CHARLIE, DOG	Naval Material Laboratory
8.5	Incendiary Effects of Atomic Bomb Tests on Building Sections at Yucca Flat	To determine the probability of primary fires resulting from a nuclear detonation in urban areas	CHARLIE, DOG	Forest Products Laboratory of the Forest Service
8.6	Sound Velocity Changes near the Ground in the Vicinity of an Atomic Explosion	To determine the velocity of sound at heights of 1.5, 10, and 54 feet above the surface at ground zero and up to 1,830 meters from ground zero, and in the interval from detonation to blast wave arrival	ABLE, BAKER, CHARLIE, DOG	Naval Electronics Laboratory
8.7	Thermal Radiation Measurement	To train employees of the Department of Engineering at UCLA in the use of thermal radiation measuring instruments being developed for Operation IVY and to collect data on the thermal radiation emitted from nuclear tests	FOX, GEORGE, HOW	Department of Engineering, UCLA

Project 8.2, Air Temperatures in the Vicinity of a Nuclear Detonation, was conducted by the Naval Radiological Defense Laboratory at Shots ABLE, BAKER, CHARLIE, and DOG. The project was designed to determine the effect of a heated air layer on the shock wave. Project personnel measured air temperatures and blast pressures (48).

Project 8.3, Thermal Radiation from a Nuclear Detonation, was conducted at Shots ABLE, BAKER, CHARLIE, and DOG by the Naval Radiological Defense Laboratory. The project, a continuation of similar studies at Operations CROSSROADS and BUSTER-JANGLE, was designed to measure the total thermal radiation and the intensity-time relationship of the radiation as a function of distance from ground zero. Project participants placed several types of instruments, including calorimeters, at various distances from ground zero. They also positioned calorimeters in the drop aircraft (49).

Project 8.3a, Thermal Radiation Measurements Using Passive Indicators, was conducted at Shot CHARLIE by the Naval Material Laboratory. The purpose was twofold:

- To evaluate the field performance of passive heat-sensitive materials in measuring the total incident thermal radiation as a function of distance from ground zero
- To test the indicators for use in determining yield, temperature, and integrated fireball flux.

Before the shot, Naval Material Laboratory participants in Project 8.4 placed indicators at various ranges from the intended ground zero. Project 8.4 personnel retrieved these instruments along with their own instruments in the CHARLIE test area after the declaration of recovery hour (41; 134).

Project 8.4, Atmospheric Transmission and Weather Measurements, was conducted at Shots BAKER, CHARLIE, and DOG by the

Naval Material Laboratory. The project was designed to provide data on meteorological conditions for use in thermal radiation projects and to supplement information supplied by Project 9.2, Air Weather Service Participation. Project personnel measured barometric pressure, temperature, humidity, and rainfall (76).

Project 8.5, Incendiary Effects of Atomic Bomb Tests on Building Sections, was performed at Shots CHARLIE and DOG by the Forest Products Laboratory of the Forest Service. The objective was to determine the probability of primary fires resulting from a nuclear detonation in urban areas. The four types of structures tested were:

- Cubicle room
- Right angle corner between walls
- Right angle corner with cornice
- Roof section.

The sections were constructed and mounted to resist demolition by the blast so that only the incendiary effects of the nuclear detonation would be shown. They were installed at stations 1,200 to 4,880 meters from ground zero.

Personnel from Lookout Mountain Laboratory took documentary photographs of the displays before each nuclear detonation. They also photographed the structures after the declaration of recovery hour, when project personnel entered the shot area to inspect the displays. Figure 4-4 shows participants examining a roof section (52).

Project 8.6, Sound Velocity Changes near the Ground in the Vicinity of an Atomic Explosion, was conducted at Shots ABLE, BAKER, CHARLIE, and DOG by the Naval Electronics Laboratory. The objective was to determine the velocity of sound at heights of 1.5, 10, and 54 feet above ground, at ground zero and up to 1,830 meters from ground zero, in the interval from detonation to blast wave arrival (129).

Figure 4-4: PROJECT 8.5 PERSONNEL EXAMINE ROOFING MATERIALS TO DETERMINE THE THERMAL EFFECTS PRODUCED BY A NUCLEAR DETONATION

Project 8.7, Thermal Radiation Measurements, was performed at Shots FOX, GEORGE, and HOW by the Department of Engineering of the University of California at Los Angeles, under contract to the Air Research and Development Command. The project was designed to train employees of the Department of Engineering in the use of thermal radiation measuring instruments being developed for Operation IVY. Another objective was to collect data on the thermal radiation emitted from nuclear tests. Data were recorded at Building 400, located near the Control Point (144).

4.1.9 Program 9: Supporting Measurements

Program 9, Supporting Measurements, assisted other Military Effects Group projects by providing weather data, timing signals, and photographs of the experiments. In addition, the program involved basic research in electromagnetic radiation. As table 4-9 indicates, four projects were conducted as part of Program 9 (134; 138).

Project 9.1, Technical and Training Photography, was conducted at TUMBLER-SNAPPER shots by personnel from the following agencies (4; 82; 134):

- Air Force Lookout Mountain Laboratory
- Army Pictorial Service Division
- Naval Medical Research Institute
- Signal Corps Engineering Laboratories
- SAC 5th Reconnaissance Technical Squadron
- SAC 28th Reconnaissance Technical Squadron
- Wright Air Development Center
- 4925th Test Group (Atomic).

Personnel from these units accompanied AFSWP participants to take photographs and motion pictures of the detonation and of Military Effects Test Group projects. In addition, the Army sent an estimated 21 men to Camp Desert Rock around 16 April to photograph the Desert Rock IV Exercise at Shot CHARLIE, and the

Table 4-9: MILITARY EFFECTS TEST GROUP PROJECTS OF PROGRAM 9 CONDUCTED DURING OPERATION TUMBLER-SNAPPER

Project	Title	Objective	Shots	Participants
9.1	Technical and Training Photography	To make still photographs and motion pictures of various Military Effects Test Group projects and Desert Rock IV military operations	All	Naval Medical Research Institute; Air Force Lookout Mountain Laboratory; Army Pictorial Service Division Wright Air Development Center; 4925th Test Group (Atomic); SAC 5th and 28th Reconnaissance Technical Squadrons, Signal Corps Engineering Laboratories
9.2	Air Weather Service Participation	To provide daily weather forecasts and data to the Test Director and to participants in other AFSWP projects	All	Air Weather Service
9.4	Effects of Atomic Explosions on the Ionosphere	To obtain data on the effects of a nuclear detonation on the ionosphere and on ionospheric radio wave propagation	All	Signal Corps Engineering Laboratories, 9471st Technical Service Unit
9.5	Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations	To determine the wave shape and the amplitude of radio frequency energy emanating from a nuclear detonation	BAKER, CHARLIE, DOG, EASY, FOX, GEORGE	Signal Corps Engineering Laboratories; 9467th Technical Service Unit

Marine Corps Provisional Atomic Exercise Unit supplied photographers to document the Desert Rock IV Exercise at Shot DOG. These photographers returned to their home stations soon after the exercises were completed (4; 123).

Project 9.2, Air Weather Service Participation, was conducted at all TUMBLER-SNAPPER shots by the Air Force. Project participants were from the 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma. Project participants provided daily weather forecasts and data to the Test Director and to participants in AFSWP projects. Figure 4-5 shows a project participant taking meteorological measurements. The organization and responsibilities of the Air Weather Service during Operation TUMBLER-SNAPPER are discussed generally in this volume in section 2.1.2 of chapter 2 and in section 4.3 of this chapter (8; 9; 82; 112).

Project 9.4, Effects of Atomic Explosions on the Ionosphere, was conducted at all TUMBLER-SNAPPER shots by the Signal Corps Engineering Laboratories, with assistance from personnel of the 9471st Technical Service Unit. The objective was to obtain data on the effects of a nuclear detonation on ionospheric radiowave propagation.

Project personnel worked at transmitter and receiver stations. The only onsite transmitter was at Station 9.4, 910 meters north of the Control Point. Two other transmitters were at Mather AFB, Sacramento, California. The radio receiver stations were at the Navaho Ordnance Depot in Flagstaff, Arizona; at White Sands Proving Ground, New Mexico; and at Fort Sill, Oklahoma. Information obtained at the stations was sent for analysis to the Signal Corps Engineering Laboratories (70; 134).

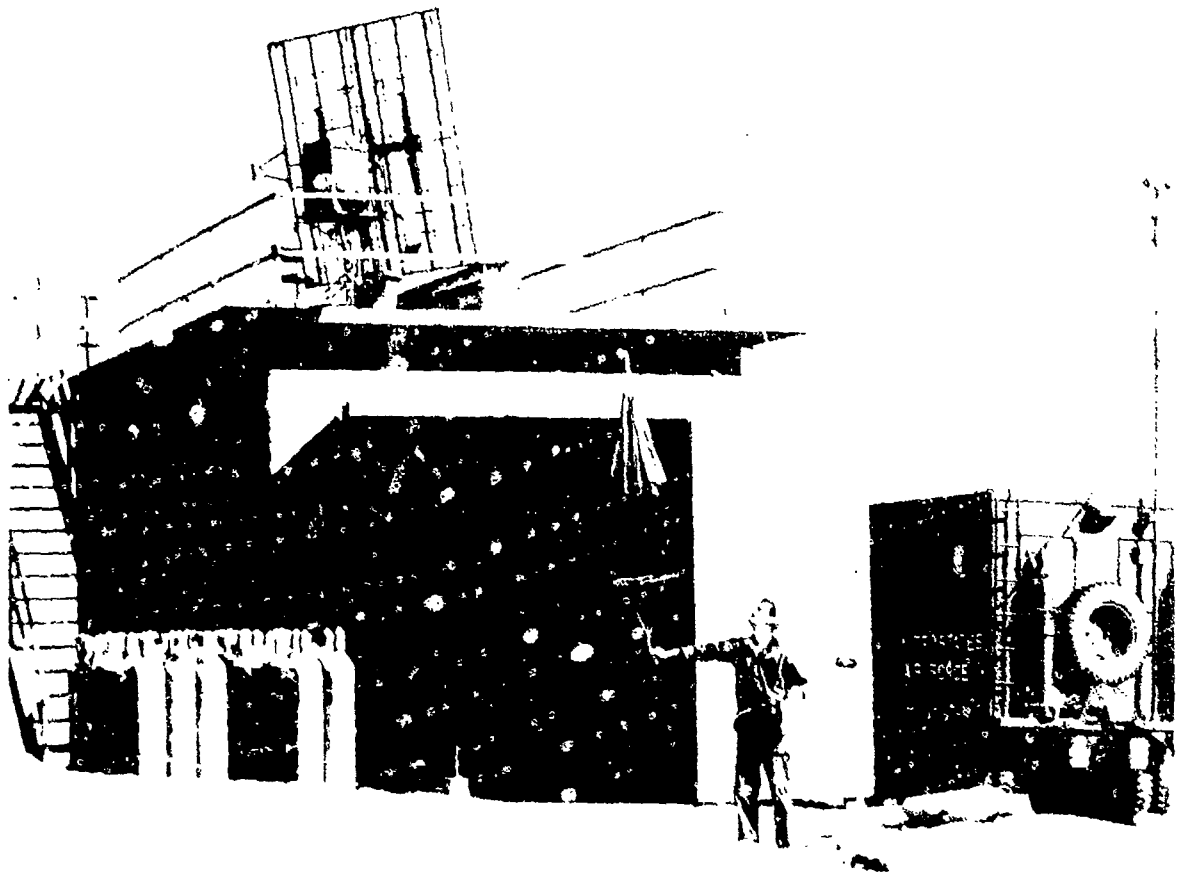

Figure 4-5: A MEMBER OF THE AIR WEATHER SERVICE TAKES METEOROLOGICAL MEASUREMENTS

Project 9.5, Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations, was conducted at Shots BAKER, CHARLIE, DOG, EASY, FOX, and GEORGE by the Signal Corps Engineering Laboratories, with assistance from the 9467th Technical Service Unit, Electronic Warfare Center. The project was designed to determine the wave shape and the amplitude of radio frequency energy emanating from a nuclear detonation. Project personnel operated two stations 16 to 25 kilometers from ground zero through the detonation. In addition, project participants manned one station at White Sands Proving Grounds, New Mexico, and another at the Evans Signal Laboratory in Belmar, New Jersey (51; 134).

4.2 DEPARTMENT OF DEFENSE INVOLVEMENT IN PROGRAMS OF THE AEC WEAPONS DEVELOPMENT TEST GROUP

Besides the AFSWP Test Command Military Effects Test Group, the joint AEC-DOD organization coordinated the activities of the Weapons Development Test Group. The Los Alamos Scientific Laboratory conducted most of the experiments of this group. DOD participation was limited to the programs listed in table 4-10.

Program 10, Measurement of Alpha, consisted of two projects conducted by the Naval Research Laboratory of Washington, D.C.:

- Project 10.1, Measurement of Alpha
- Project 10.2, Test of Scintillator Optical Path Technique.

Project 10.1 was conducted at Shots BAKER, CHARLIE, DOG, EASY, FOX, and HOW (114).

Project 10.2 was performed at Shots FOX and GEORGE to evaluate experimental equipment for use at Operation IVY, scheduled for the fall of 1952. This experiment measured the light output of a nuclear detonation. Experimental equipment had to be

Table 4-10: WEAPONS DEVELOPMENT TEST GROUP PROJECTS WITH DOD PARTICIPATION, OPERATION TUMBLER-SNAPPER

Program Title \ Shot Names	ABLE	BAKER	CHARLIE	DOG	EASY	FOX	GEORGE	HOW
Program 10, Measurement of Alpha		10.1	10.1	10.1	10.1	10.1 10.2	10.2	10.1
Program 11, Measurement of Transit Time		11.1	11.1	11.1	11.1	11.1	11.1	11.1
Program 12, Technical Photography	12.1 12.1c	12.1 12.1c 12.2a-d	12.1 12.1c 12.2a-d	12.1 12.1c 12.2a-d	12.1 12.1c 12.2a-d	12.1 12.1c 12.2a-d	12.1 12.1c	12.1 12.1c 12.2a-d
Program 13, Radiochemistry Sampling	13	13	13	13	13	13	13	13
Program 14 Test of an External Initiator						14	14	
Program 15, Delayed Gamma Ray Measurements		15.2	15.2 15.3	15.2 15.3	15.2 15.3	15.2	15.2 15.3	15.2
Program 17, Neutron Measurements				17.1 17.2	17.1 17.2	17.1 17.2	17.1 17.2	17.1 17.2
Program 18, Thermal Radiation Measurements	18.1 18.4	18.1 18.3 18.4	18.1 18.4	18.1 18.3 18.4	18.1 18.3 18.4	18.1 18.4	18.1 18.3 18.4	18.1 18.3 18.4
Program 19, Blast Measurements	19.1a 19.1c-d 19.2a-b 19.2d 19.2f	19.1a 19.1c-d 19.1e 19.2a-b 19.2c 19.2d 19.2f	19.1a 19.1c-d 19.1e 19.2a-b 19.2c 19.2d 19.2f	19.1a 19.1c-d 19.1e 19.2a-b 19.2c 19.2d 19.2f	19.1c-d 19.1e 19.2a-b	19.1c-d	19.1c-d	19.1c-d 19.2a-b

located within about ten meters of ground zero, where the levels of gamma radiation far exceeded those of any other type of radiation. Shot-day recovery operations were not necessary. Results of the experiment indicated that the equipment was not suitable for use at Operation IVY (115).

Program 11, Measurement of Transit Time, also consisted of two projects, but only one experiment involved DOD personnel. Project 11.1, Measurement of Transit Time, was conducted by the Naval Research Laboratory at Shots BAKER, CHARLIE, DOG, EASY, FOX, GEORGE, and HOW (114).

Program 12, Technical Photography, was conducted at all shots by personnel from EG&G. They provided technical photography support, including dust studies, preshock turbulence studies, light absorption and mirage studies, fireball growth measurement, thermal effects studies, and other technical still and motion picture coverage required by the Weapons Development Test Group.

Two days before each shot, project personnel at the Control Point prepared the film to be used on shot-day. The afternoon before the nuclear test, project personnel loaded film into remote-controlled cameras located at stations in the shot area. After the detonation, they recovered the exposed film and processed some of it in the mobile unit set up in the Control Point area. The remaining film was flown to civilian laboratories for processing (90).

Project 12.1c, Bhangmeter Mod II, was conducted at all shots by EG&G. The objective was to evaluate and test new bhangmeter equipment. Project personnel installed these instruments for measuring the yield characteristics of a detonation at the Control Point for all shots and in the drop aircraft for Shots ABLE, BAKER, CHARLIE, and DOG. Bhangmeter readings recorded at shot-time were removed and analyzed after the shot (89).

Project 12.2a-d, High-speed Photography, was conducted at Shots BAKER, CHARLIE, DOG, EASY, FOX, and HOW by LASL and EG&G. The objectives were to study early fireball growth and obtain measurements correlating shock arrival times with the appearance of the fireball. Project personnel mounted special cameras in a trailer about four kilometers from ground zero at Shots BAKER, CHARLIE, and DOG. At Shot EASY, they installed cameras in trailers 1.6 and 3.2 kilometers from the shot-tower. Personnel at FOX placed cameras in a bunker 460 meters from the shot-tower and in a trailer 3.2 kilometers southeast of the shot-tower. At Shot HOW, they mounted cameras in a trailer 3.2 kilometers from the shot-tower. After the detonations, personnel retrieved the film for analysis (84).

Program 13, Radiochemistry Sampling, required cloud sampling at all TUMBLER-SNAPPER shots. The program was supported by AFSWC pilots and aircraft and is discussed in section 4.3 of this report (82; 134).

Program 14, Test of an External Initiator, was conducted by LASL at Shots FOX and GEORGE (39).

Program 15, Delayed Gamma Ray Measurements, was conducted by LASL. DOD personnel, apparently assigned to LASL, participated in two projects.

Project 15.2, Gamma Radiation Exposure as a Function of Distance, was conducted at Shots BAKER, CHARLIE, DOG, EASY, FOX, GEORGE, and HOW. The objective was to measure gamma radiation exposure at different distances from the detonation. Project personnel placed gamma-detecting instruments in the ground at various distances from ground zero and recovered these instruments after the detonation (154).

Project 15.3, Radiation Monitoring Measurements, was conducted at Shots CHARLIE, DOG, FOX, and HOW. The objectives were to monitor gamma radiation levels from the radioactive fallout after a nuclear detonation and to test several prototype radiation monitoring instruments for use at Operation IVY. The information on radiation levels was also used by recovery parties. Project personnel installed recording equipment in stations located at various distances from ground zero. The recording equipment was set up to telemeter information on gamma radiation levels to the Control Point (121).

Program 17, Neutron Measurements, was conducted by the Los Alamos Scientific Laboratory. Projects 17.1 and 17.2, External Neutron Measurements, had DOD participants at Shots DOG, EASY, FOX, GEORGE, and HOW. The objective of these projects was to use threshold detectors to measure external neutron flux as a function of distance. LASL also provided some threshold detectors to the Naval Radiological Defense Laboratory for Project 4.3 and to the Naval Research Laboratory for Project 2.3.

Project personnel attached some threshold detectors to horiozontal steel bars about four feet above the ground, some to a steel cable, and some to stakes. Other detectors were placed in the ground. Project participants also installed an underground shelter containing oscilloscopes set to run automatically at shot-time. After the detonations, project personnel recovered the threshold detectors and the records from the underground shelter. AFSWC couriers flew the detectors to LASL for analysis (69).

Program 18, Thermal Radiation Measurements, consisted of six projects, all conducted by the Naval Research Laboratory:

- Project 18.1, Total Thermal Radiation and Atmospheric Transmission
- Project 18.2, Power as a Function of Time

- Project 18.3, Color Temperatures
- Project 18.4, High-resolution Spectroscopy
- Project 18.5, Air Temperature versus Time
- Project 18.6, Light Absorption Characteristics.

Of these six projects, detailed documentation has been located for Projects 18.1, 18.3, and 18.4.

Project 18.1, Total Thermal Radiation and Atmospheric Transmission, was conducted at all eight shots to obtain information on the transmission of light and thermal radiation emitted by nuclear detonations of various yields. To measure the transmission of light, project personnel placed one photoelectric brightness meter at the Control Point and another in Area 2 of the NPG. In addition, they installed a transmissometer near the BUSTER-JANGLE Y and a receiver at the Control Point. Participants manually operated the instruments at the Control Point during the shots. They shut down equipment after the shots to analyze recorded data (122).

Project 18.3, Color Temperatures, was conducted at Shots BAKER, DOG, EASY, GEORGE, and HOW to measure the spectral characteristics of the nuclear fireball as a function of time. Measurements were taken with a high-speed spectrograph (86).

Project 18.4, High-resolution Spectroscopy, was conducted at all eight shots to supplement information obtained from spectroscopy measurements taken during previous nuclear weapons testing series, such as Operations GREENHOUSE and BUSTER-JANGLE. Personnel installed a spectrograph at the Control Point (43).

Program 19, Blast Measurements, involved several projects in which DOD personnel participated:

- Project 19.1a, Air Shock Pressure--Time versus Distance

- Projects 19.1c and 19.1d, Sandia Laboratory Shock-gauge Evaluations Tests
- Project 19.1e, Air Shock Pressures as Affected by Hills and Dales
- Projects 19.2a and 19.2b, Blast-wave Material Velocity Measurements
- Project 19.2c, Beta-densitometer Feasibility Test
- Project 19.2d, Interferometer-gauge Pressure-time Measurements
- Project 19.2f, Measurement of Preshock Sound Velocity.

Project 19.1a, Air Shock Pressure--Time versus Distance, was conducted by the Sandia Corporation at Shots ABLE, BAKER, CHARLIE, and DOG. Representatives of LASL, AFSWP, the Stanford Research Institute, the Naval Ordnance Laboratory, and the Ballistic Research Laboratories helped to plan this project. The objective was to obtain pressure measurements to show the relationship between air shock pressure and height of burst. Project personnel installed pressure gauges in the ground and on towers along radial lines extending from ground zero. At the instant of burst, information from the gauges was telemetered to a recording station where it was monitored by project personnel (132).

Projects 19.1c and 19.1d, Sandia Laboratory Shock-gauge Evaluations Tests, were conducted at all TUMBLER-SNAPPER shots. Personnel from LASL and contractors assisted Sandia in calibrating and installing instruments. The project was intended to develop and test new instruments for collecting information on dynamic and static pressures, wind directions, sound and wind speeds, and temperature rises resulting from a shock wave. At Shots ABLE through DOG, project personnel installed instruments at two stations; at EASY through HOW, only one station was instrumented. Cables connected the instruments to equipment that recorded the information (68).

Project 19.1e, Air Shock Pressures as Affected by Hills and Dales, was conducted at Shots BAKER, CHARLIE, DOG, and EASY by personnel from Sandia Corporation and contractors of the NPG. The objective was to collect more information about the influence of hills and valleys on the shock waves from airbursts and to study the shielding effects of hills. Project personnel installed gauges to record air shock pressure at two sites. Cables connected the gauges to recording equipment in a nearby mobile van. Sometime after the detonation, project participants recovered the records from the van (130).

Projects 19.2a and 19.2b, Blast-wave Material Velocity Measurements, were conducted at Shots ABLE, BAKER, CHARLIE, DOG, EASY, and HOW by LASL. The objective was to photograph peak overpressure phenomena associated with a nuclear burst. An officer and six men from the Antiaircraft Artillery and Guided Missile Center, Fort Bliss, Texas, installed and maintained a 90-millimeter gun battery. EG&G provided photography services.

Project personnel emplaced mortars and 90-millimeter guns along a blast line extending from ground zero. Smoke canisters were fired into the air from these mortars and guns immediately before the burst so that air disturbances would be visible. An electronic timing device fired the mortars and guns. The camera stations were also electronically operated (139).

Project 19.2c, Beta-densitometer Feasibility Test, was conducted at Shots BAKER, CHARLIE, and DOG by personnel from LASL, assisted by Army personnel. The objective was to test two types of densitometers and to measure air density as a function of time after passage of a shock wave. The densitometers, connected to recording equipment, were installed in the ground near the target area used for Shots BAKER, CHARLIE, and DOG. They were set to start functioning upon receipt of a timing signal. After the burst, project personnel entered the area to recover instruments and records (139).

Project 19.2d, Interferometer-gauge Pressure-time Measurements, was conducted at Shots ABLE, BAKER, CHARLIE, and DOG by LASL (139).

Project 19.2f, Measurement of Preshock Sound Velocity, was conducted at Shots ABLE, BAKER, CHARLIE, and DOG by LASL, with Air Force participation. The objective was to measure the velocity of sound in the air near the ground before the shock wave from the detonation arrived. Project personnel installed oscillators and recording equipment at several stations near ground zero. After the detonation, project personnel recovered the records from the instrument stations (139).

4.3 AIR FORCE SUPPORT MISSIONS AT OPERATION TUMBLER-SNAPPER

The Air Force, particularly the Air Force Special Weapons Center, played a major operational and support role in many of the scientific and military test programs conducted at the Nevada Proving Ground during Operation TUMBLER-SNAPPER. Based at Kirtland AFB in Albuquerque, New Mexico, AFSWC used Indian Springs AFB in Nevada as its principal staging area during the testing. AFSWC provided most of the aircraft and personnel required for aircraft operational control, airdrop delivery, cloud sampling, courier missions, cloud tracking, aerial surveys of the terrain, weather reconnaissance, and other air support requested by the joint AEC-DOD organization. The principal AFSWC units involved were the 4925th Test Group (Atomic) and the 4901st Support Wing. AFSWC participation is summarized in table 4-11 (8-10; 19; 82; 83).

The Air Operations Center, staffed by personnel from the 4925th Test Group (Atomic) and located at the Control Point, exercised operational control over all aircraft participating in

Table 4-11: AFSWC MISSION SUPPORT AT OPERATION TUMBLER-SNAPPER

Mission	Project/ Program	ABLE	BAKER	CHARLIE	DOG	EASY	FOX	GEORGE	HOW
Air Drop B-50		•	•	•					
B-45					•				
Disaster Aircraft C-47		•	•	•	•				
Cloud Sampling	13	•	•	•	•	•	•	•	•
	73	•	•	•	•	•	•	•	•
Courier Service	19	•	•	•	•				
	23			•	•				•
	63					•	•	•	
	73	•	•	•	•	•	•	•	•
	91				•				
	13	•	•	•	•	•	•	•	•
	171				•	•	•	•	•
Cloud Tracking		•	•	•	•	•	•	•	•
Aerial Survey of Terrain		•	•	•	•	•	•	•	•

Operation TUMBLER-SNAPPER. The 4925th also supported the tests by:

- Providing, maintaining, and operating the B-45 and B-50 bomb delivery aircraft and the spare aircraft for bomb delivery
- Controlling the operations of the C-47 disaster aircraft that routinely accompanied bomb drop aircraft on their missions
- Providing, maintaining, and operating the B-29 and T-33 sampling aircraft
- Training pilots of Task Group 132.4 (Provisional) in cloud sampling for future participation in Operation IVY, an oceanic test series
- Supervising cloud-tracking operations
- Operating aircraft for terrain surveys.

The 4925th was also responsible for radiological safety operations at Indian Springs AFB, as discussed in chapter 5. The 4925th had approximately 100 personnel on temporary duty at Indian Springs AFB (8; 9; 82; 88; 155).

The 4901st Support Wing, based at Kirtland AFB, was responsible for most of the logistics and maintenance required for the air operations. The responsibilities of the 4901st included:

- Supplying the 4925th at Indian Springs AFB with additional personnel and equipment
- Providing the disaster aircraft and crew that accompanied the bomb drop aircraft
- Providing courier and air shuttle service between Indian Springs AFB and Kirtland AFB and between Indian Springs AFB and Yucca Lake airstrip
- Supplying instrumented C-47 aircraft with crews for aerial surveys of the terrain.

In addition, the 4901st was responsible for radiological safety operations at Kirtland AFB, as discussed in chapter 5. In

connection with its radiological safety duties, the 4901st trained 35 pilots of Task Group 132.4 (Provisional) in radiological procedures. These pilots were to participate later that year in Operation IVY. During TUMBLER-SNAPPER, approximately 300 personnel from the 4901st Support Wing were stationed at Indian Springs AFB (8; 9; 82; 88; 155).

Other participating Air Force units contributed aircraft, flight crews, and ground crews. One of the larger units was the 55th Weather Reconnaissance Squadron, which provided aircraft for cloud-tracking missions. Squadron personnel stationed at McClellan AFB, California, flew to Indian Springs AFB two days before each shot. Thirty-two personnel participated at each of the first three shots, and 28 personnel took part in each of the remaining shots (8; 9; 82; 88; 155).

The Strategic Air Command furnished 24 B-50 aircraft and a number of B-29 and B-36 aircraft for its own photography and crew indoctrination projects during all shots except EASY. The aircraft were from Castle AFB, California; Barksdale AFB, Louisiana; Travis AFB, California; Walker AFB, New Mexico; Carswell AFB, Texas; and Biggs AFB, Texas. A unit of the Strategic Air Command, the 12th Fighter-Escort Wing, which was to participate in the upcoming Operation IVY, provided five F-84G aircraft and pilots to train in sampling procedures. These aircraft and personnel were from Bergstrom AFB, Texas (8-10; 19; 24; 82; 88; 109; 140; 155).

The Air Weather Service provided the Test Director with meteorological information important in scheduling the detonations, such as specific data on wind and cloud conditions. The 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma, directed the meteorological analysis from the Control Point Weather Station. Eight forecasters, 13 observers, and 14 other Air Force personnel operated special equipment

at the Control Point. Eleven Air Force personnel operated a weather station in Tonopah, Nevada. Weather stations in Beatty, Caliente, Crystal Springs, Currant, and Warm Springs, Nevada, and St. George, Utah, were each operated by three airmen. These personnel were part of Project 9.2, Air Weather Service Participation, discussed in chapter 2 of this volume and in section 4.1.9 of this chapter (112).

Project 9.2 personnel gave the Test Director hourly weather reports before and immediately after each detonation. They also provided 24-hour and 48-hour weather forecasts. In addition, Air Weather Service personnel compiled data from onsite and offsite stations into maps showing wind direction, wind speed, cloud paths, and other meteorological data (8; 9; 88; 112; 155).

Airdrop and Disaster Missions

The 4925th Test Group (Atomic) provided, maintained, and operated B-45 and B-50 bomb delivery aircraft for Shots ABLE, BAKER, CHARLIE, and DOG. Taking off from Kirtland AFB several hours before shot-time, the drop aircraft flew over unpopulated areas before entering an orbit pattern over the Nevada Proving Ground. After releasing the nuclear device, the aircraft returned to Kirtland AFB (8; 9; 82; 88; 109; 155).

Accompanying the drop aircraft was a C-47 disaster aircraft, provided and operated by the 4901st Support Wing. This aircraft generally left Kirtland AFB before the drop aircraft and orbited over Las Vegas while the drop aircraft completed its mission. The disaster team was to protect the weapon and monitor radiation contamination in an emergency situation, such as the crash of the bomb-carrying aircraft or the unplanned release of its weapon. The disaster team plotted the position of the drop aircraft during its mission. Soon after the drop aircraft had successfully completed its mission, the disaster aircraft returned to Kirtland AFB (8; 9; 82; 88; 109; 155).

Cloud Sampling

An important objective of Operation TUMBLER-SNAPPER was to obtain samples of fission products from nuclear detonations so that the yield and efficiency of the nuclear devices could be determined. The task of collecting samples of particulate and gaseous debris from the clouds resulting from the detonations was assigned to the 4925th Test Group (Atomic), which used B-29 and T-33 aircraft to perform the sampling. The 4925th collected samples of the clouds for Military Effects Test Group Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, and Weapons Development Test Group Program 13, Radiochemistry Sampling. In addition, pilots from Air Force Task Group 132.4 flew F-84 sampler aircraft as training for cloud sampling to be conducted at Operation IVY in the fall of 1952 (8; 9; 82; 88; 109; 134; 155).

The TUMBLER-SNAPPER cloud-sampling procedures were modifications of procedures used during Operation BUSTER-JANGLE. While jet aircraft were used only experimentally for cloud sampling during BUSTER-JANGLE, they were the primary sampling aircraft for TUMBLER-SNAPPER. Jet aircraft were more effective samplers for several reasons:

- Fewer personnel were exposed to nuclear radiation because of the smaller crew (eight crew members in a B-29 versus two in a T-33).
- The greater speed allowed a sampling team to collect more samples before reaching its maximum allowable radiation exposure.
- The higher altitude capability resulted in the collection of samples that formerly could not be obtained.
- Fresher samples were obtained because the jet aircraft were faster in returning the samples to the landing strip for air shipment to the research laboratory.

In another modification of BUSTER-JANGLE procedures, a control aircraft was used to direct samplers to the cloud.

Operation TUMBLER-SNAPPER was the first series in which the control aircraft directed the samplers in cloud penetration. Previously, the Air Operations Center had performed this function (8; 9; 82; 88; 109; 155).

For the Weapons Development Test Group sampling missions, 4925th Test Group pilots collected samples on filter papers in the specially modified wing-tip tanks of T-33 and F-84 aircraft. The aircraft had valves that could be opened to allow an air-stream to pass through the wing-tip tank. The radioactive particles from the cloud became trapped in the filter paper held by a grid within this tank. A radiation detection meter located in the wing-tip tank and connected to an instrument in the cockpit indicated to the pilot the radiation intensities of the sample collected. After the sampling was completed, the aircraft returned to Indian Springs AFB, where the filter papers containing the particulate samples were removed and sent promptly by courier aircraft to LASL for analysis (8; 9; 82; 88; 109; 155).

For AFSWP Project 7.3, gaseous samples also had to be collected. A B-29 was equipped with a cylindrical metal container for trapping gases as the aircraft flew through the cloud. The B-29 aircraft was suited for the mission because its long-range capability enabled it to stay aloft near the cloud for the time required to complete the sampling. The gaseous and particulate samples of the cloud were distributed to LASL scientists for analysis (82; 150).

The standard procedures for cloud sampling are described in the following paragraphs. Shot-specific information on sampling is contained in the TUMBLER-SNAPPER multi-shot volumes.

About 90 minutes before the detonation, a B-29 sampler control aircraft, probably with a crew of nine, took off from Indian Springs AFB. The aircraft climbed to an altitude of about

25,000 feet and orbited above Indian Springs AFB until shot-time. A sampler director, a flight surgeon, and a scientific advisor from LASL augmented the crew.

After the detonation, the sampler control aircraft followed the cloud and observed its formation and dissipation. During this time, the scientific advisor evaluated the cloud structure and determined the cloud areas from which sampler aircraft were to collect particulate and gaseous samples. The sampler aircraft were on standby at Indian Springs AFB. On advice from the sampler control aircraft, the Air Operations Center alerted the sampler aircraft to take off. The center would then vector the samplers to the approximate location of the control aircraft.

As the sampling aircraft rendezvoused with the B-29 control aircraft, the control aircraft would direct the sampler aircraft to make one or more penetrations of the cloud at various altitudes and areas to gather particulate and gaseous nuclear debris.

After the mission was completed, the control aircraft directed the sampler aircraft to Indian Springs AFB. When the aircraft landed, the samples were removed and packaged for delivery to LASL or Air Force laboratories for analysis. The sampler control aircraft was usually the last to land (8; 9; 82; 83; 88; 109; 155).

Courier Service

The AFSWC courier service, provided by the 4901st Support Wing, delivered cloud samples and experimental material from TUMBLER-SNAPPER research projects to laboratory facilities, such as the Los Alamos Scientific Laboratory and the Naval Research Laboratory. AFSWC supplied courier service aircraft and aircrews to Projects 1.9, 2.3, 6.3, 7.3, and 9.1 and to Programs 13 and 17 (8-10; 134).

Cloud Tracking

The 4901st, using one B-25, and the Air Weather Service, using two B-29s, conducted cloud-tracking missions. Their objective was to record the path of the cloud resulting from a detonation and to monitor the cloud's radiation intensity in order to expedite airway clearance for commercial aircraft. The B-25 had a crew of five, including a radiological safety monitor from Test Command. The B-29s each had a crew of about ten, including a radiological safety monitor. The aircraft, which were furnished by AFSWC and the 55th Weather Reconnaissance Squadron, March AFB, staged from Indian Springs AFB.

Cloud-tracking procedures were standard for every shot, although they were sometimes modified because of differences between the estimated and actual yield of a detonation. The B-25 tracked the lowest part of the cloud stem, while one of the B-29s observed the cloud from its stem to its top. The second B-29 aircraft was held in reserve near the cloud in case either the B-25 or the B-29 aircraft had a mechanical failure or in case the cloud had to be tracked in different directions.

The B-25 aircraft tracked the cloud visually as long as possible. When the cloud was no longer visible, highly sensitive air-conductivity and scintillation-counter instruments were used to detect the cloud. These instruments included:

- AN/PDR-T1B ion chamber
- AN/PDR-2610A gamma survey meter
- Beckman MX-5 beta-gamma survey meter.

The two B-29 aircraft usually followed the cloud a few hundred kilometers from the point of detonation. To track the cloud, the aircraft flew back and forth along the edges of the cloud, changing direction every two or three minutes. When detectors aboard the aircraft gave measurable readings, the tracker turned away without actually penetrating the cloud. The position, time, altitude, and maximum intensity readings of the

cloud were reported back to the Air Operations Center at the Control Point, where the information was used to plot the cloud dimensions and course.

By repeating this procedure throughout the mission, the cloud trackers determined the movement and extent of the cloud. The cloud was tracked either until it dissipated or until the Test Manager directed the trackers to stop. The B-25 and the B-29s then returned to Indian Springs AFB (8-10; 82; 88; 109; 155).

Aerial Surveys of Terrain

Following each nuclear event, several aircraft made low-altitude radiation surveys of the terrain in and around the Nevada Proving Ground. These surveys helped determine when ground parties could safely enter the test area after the shot. AFSWC provided aircrews and several types of aircraft for this activity, including YH-12, C-45, L-20, and C-47 aircraft. The Strategic Air Command also provided four radiological safety officers and two airmen to AFSWC. Instructors from AFSWC and from the 1009th Squadron (March AFB) trained the crews in the use of specialized radiac equipment, and the 4925th Test Group (Atomic) conducted training flights for this mission.

According to the standard operating procedure for aerial surveys of the terrain, helicopters and other aircraft would make low-level surveys of the immediate target area to determine radiological conditions after each detonation. The Test Manager determined the departure times of the various aircraft and their patterns of flight. The helicopters took off from a pad east of the Control Point. Constant radio contact with the Air Operations Center at the Control Point was mandatory during these missions. Data collected in flight were radioed to the Air Operations Center. Following the mission, the helicopters landed at the Control Point pad for decontamination before returning to Indian Springs AFB (8-10; 82; 83; 88; 109; 155).

CHAPTER 5

RADIATION PROTECTION AT OPERATION TUMBLER-SNAPPER

To protect TUMBLER-SNAPPER personnel from the ionizing radiation associated with the detonation of a nuclear device, the joint AEC-DOD organization developed radiological safety policies and procedures. The purpose of the various radiation protection procedures was to minimize the exposure of individuals to ionizing radiation while still allowing them to accomplish their objectives during the testing.

Exercise Desert Rock IV participants, the test groups, and AFSWC conducted different types of activities. Despite those differences, these three groups followed similar radiation protection procedures. These procedures included:

- Orientation and training: preparing radiation monitors for their work and familiarizing other participants with radiological safety procedures
- Personnel dosimetry: issuing and processing film badges and evaluating the gamma radiation exposures measured by these devices
- Use of protective equipment: providing protective equipment, including clothing and respirators
- Monitoring: performing radiological surveys and controlling access to radiation areas
- Briefing: informing observers and project personnel of radiological exposure potentials and the current radiological conditions in the test area
- Decontamination: containing, removing, and disposing of contamination on personnel, vehicles, and equipment.

The Department of Defense performed all onsite radiological safety activities during Operation TUMBLER-SNAPPER. In addition, the AFSWP Radiological Safety Group was involved in offsite

radiological safety activities within 320 kilometers of the Nevada Proving Ground. The Atomic Energy Commission and Test Command, AFSWP, established radiological safety criteria for positioning personnel at nuclear detonations (91).

5.1 RADIATION PROTECTION FOR EXERCISE DESERT ROCK IV

The AEC was responsible for the overall operation of the NPG, including the radiological safety of all Desert Rock IV participants. Through AFSWP, the AEC established criteria to protect Exercise Desert Rock IV participants from the thermal, blast, and radiation effects of the TUMBLER-SNAPPER nuclear tests. A 24 March 1952 letter from Headquarters, Test Command, AFSWP, addressed the physical and radiological safety of Desert Rock participants. The letter established a maximum radiation exposure limit of 3.0 roentgens for Desert Rock IV troops during the exercise. The AEC set a requirement that maneuver troops and troop observers be at least 6,400 meters from ground zero during Operation TUMBLER-SNAPPER detonations (25; 58; 108; 134).

5.1.1 Orientation and Briefing

The Exercise Desert Rock IV Instructor Group conducted four orientation sessions for observers and exercise and support troops, covering basic characteristics and effects of nuclear weapons, as well as personal protection procedures and related medical issues. In addition, the Instructor Group accompanied participating troops and observers on a tour of the shot area a few days before the detonation.

The orientation sessions had several deficiencies. To begin with, the instructors were not organized soon enough to prepare their teaching materials. The instructors who conducted the first two courses were not thoroughly familiar with nuclear weapons effects. Experienced AFSWP instructors were not

available until the third orientation session, from 12 to 24 May. Finally, the Camp Desert Rock training aids were inadequate (42; 108).

5.1.2 Personnel Dosimetry

Desert Rock personnel entering the forward area during Operation TUMBLER-SNAPPER were to wear film badges to measure their exposure to ionizing radiation. The Signal Section obtained film badges from the AFSWP Radiological Safety Group and issued them to participants no later than 1800 hours on the day before the shot. After the troops had completed their activities and returned to Camp Desert Rock, Signal Section personnel collected the film badges by 1800 hours on shot-day. The Signal Officer then returned the badges to the AFSWP Radiological Safety Group, which processed and interpreted them to determine individual exposure to radiation (91; 108).

5.1.3 Protective Equipment

According to the operations orders and the Desert Rock Final Report of Operations, Desert Rock troops entering the forward area on shot-days carried protective masks, which were worn on command. Figure 5-1 shows Marines rehearsing use of protective masks before the maneuver at Shot DOG. Although Desert Rock troops wore no special protective clothing, they were required to keep their standard fatigues tucked securely into their boot tops and to keep their sleeves and collars tightly buttoned to minimize contamination of underclothing and skin (102; 103; 108).

5.1.4 Monitoring

Radiological ground surveys of the test area generally began after the shock wave passed and when the Test Director gave

Figure 5-1: MARINES REHEARSE USE OF PROTECTIVE MASKS BEFORE THEIR MANEUVER

permission. At Shots ABLE, BAKER, EASY, and HOW, the AFSWP Radiological Safety Group conducted all radiological monitoring. At Shots CHARLIE, DOG, and FOX, Desert Rock monitors accompanied monitors from the AFSWP Radiological Safety Group during initial surveys of the Desert Rock area. At Shot GEORGE, however, the Desert Rock monitors conducted the initial survey of the maneuver area without AFSWP supervision (91; 108).

Whenever Desert Rock troops entered radiation areas, Sixth Army Chemical, Biological, and Radiological monitors preceded the troops and surveyed routes of approach to and through radiation areas. The monitors notified the Exercise Director by radio when it was safe for troops to advance toward ground zero. The forward limit for Desert Rock personnel was the 0.5 roentgen-per-hour (R/h) radiation line (91; 102; 103; 108).

5.1.5 Decontamination

The objective of decontamination procedures at Exercise Desert Rock IV was to ensure that no troops or vehicles left the forward area of the Nevada Proving Ground with radioactivity in excess of established limits. For all shots, the limit of personnel and vehicle contamination was 0.01 R/h.

After troops had finished their maneuvers or their tour of equipment displays, they returned to the trench area, where their clothing was brushed to remove dust. Monitors then surveyed personnel, using AN/PDR-T1B meters, which they held about five centimeters from the surface being surveyed. Personnel who still exceeded the prescribed radiation limit were sent to the decontamination station operated by Army monitors and the Engineer Section. This station was one kilometer north of the Control Point at Yucca Pass, UTM coordinates 848888. There they were required to shower and change their clothing. Monitors checked these individuals after they had showered to ensure that intensities had been reduced to the prescribed limit.

Vehicles and equipment were also first brushed in the forward area to remove dust. If this measure failed to reduce the radiation intensities to 0.01 R/h or lower, vehicles were driven onto a rock bed at the decontamination station and washed with detergent and water. After each washing, monitors measured the contamination level with portable survey instruments. If repeated washings would not reduce contamination to permissible levels, the vehicles were isolated and allowed to stand until radioactive decay reduced contamination levels to 0.01 R/h or lower. When radiation levels had been reduced below that limit, the vehicles were returned to service at Camp Desert Rock (102; 103; 108).

5.2 RADIATION PROTECTION FOR THE JOINT AEC-DOD ORGANIZATION

The Test Director was responsible for the radiological safety of all members of the joint AEC-DOD organization at the Nevada Proving Ground during Operation TUMBLER-SNAPPER. The gamma exposure limit established for TUMBLER-SNAPPER participants was 3.0 roentgens, with the exception of the cloud-sampling pilots and crew who were permitted to receive exposures up to 3.9 roentgens.* To ensure that both onsite and offsite radiological safety procedures were followed, the Department of Defense established the Radiological Safety Group (25; 134).

The Radiological Safety Group was organized as shown in figure 5-2. Appointed by AFSWP, the Radiation Safety Director implemented the Test Director's radiation protection policy, which addressed the radiological safety of all persons within 320 kilometers of the Nevada Proving Ground. To implement this policy, the Radiation Safety Director supervised and

*The radiological safety report indicates that 3.9 roentgens was the established limit at TUMBLER-SNAPPER (91). However, this limit, except for the sampling crews, has not been verified in any other pre- or post-action report.

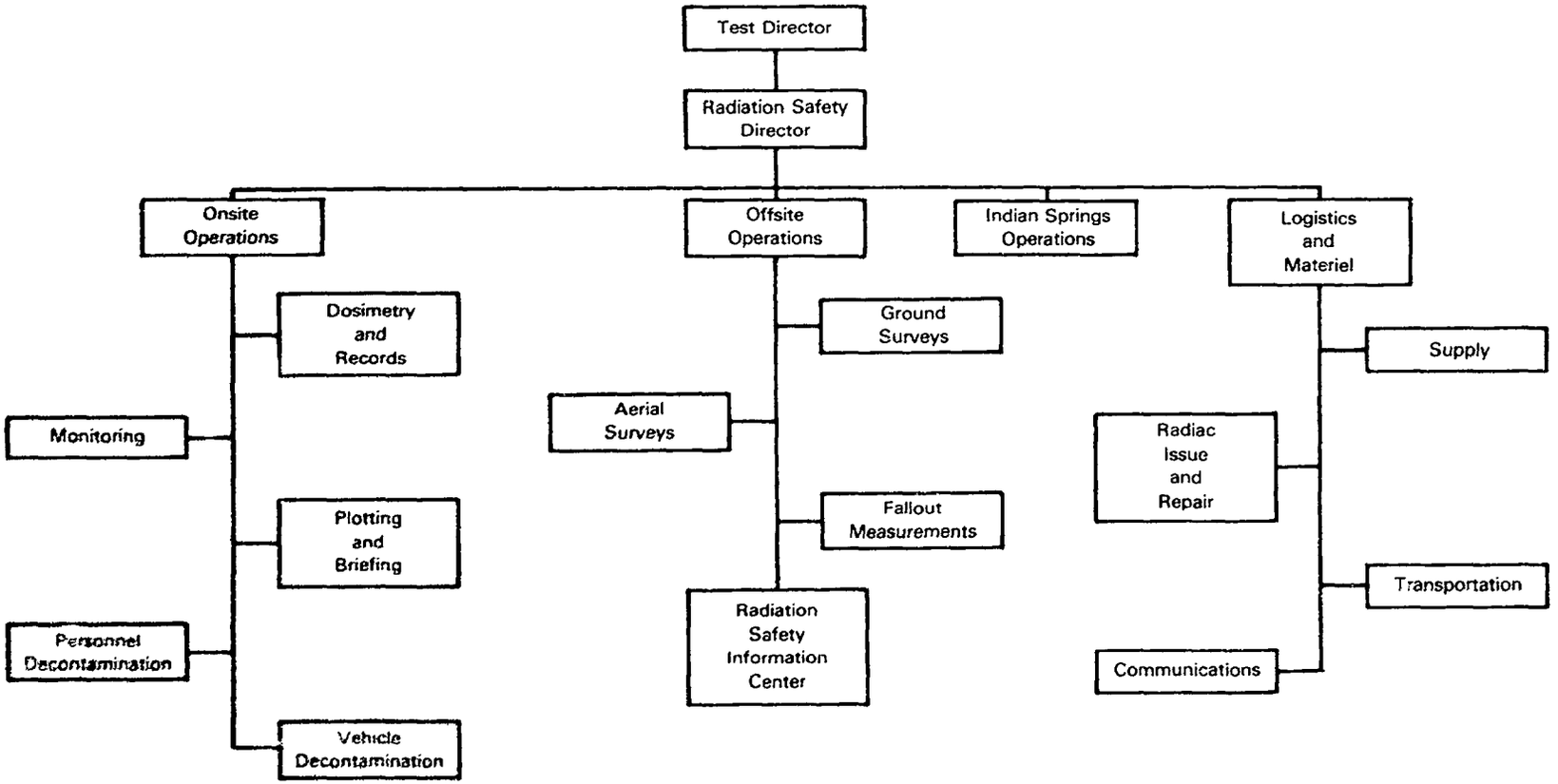

Figure 5-2: AFSWP RADIOLOGICAL SAFETY ORGANIZATION

coordinated all activities of the Radiological Safety Group and informed the Test Director of onsite and offsite radiological conditions. The Radiation Safety Director was also responsible for radiological safety operations at Indian Springs AFB (91; 134).

The following elements made up the AFSWP Radiological Safety Group (53; 91):

- 216th Chemical Service Company, consisting of four officers and 134 enlisted men from Rocky Mountain Arsenal, Colorado
- 995th Quartermaster Laundry Company Detachment, involving one officer and 14 enlisted men from Fort Devens, Massachusetts
- 17th Chemical Technical Intelligence Detachment, consisting of two officers and seven enlisted men from the Army Chemical Center, Maryland
- Five officers and five enlisted men from the Department of the Navy
- Ten officers from the Department of the Air Force
- Three officers and seven enlisted men from Test Command, AFSWP
- Five officers from Headquarters, AFSWP.

The activities performed by the AFSWP Radiological Safety Group included (91):

- Advising the Test Director on measures to ensure the radiological safety of all personnel involved in the operation
- Furnishing all ground monitoring services for both scientific programs and radiological safety procedures within a 320-kilometer radius of the NPG
- Providing current radiological situation charts and maps showing onsite and offsite data obtained by ground and aerial surveys of the terrain
- Issuing, processing, and maintaining records of all personnel dosimeters

- Operating decontamination facilities for personnel, vehicles, and equipment
- Receiving reports from cloud-tracking aircraft to advise the Test Director of the need to close air lanes
- Packaging radioactive material for shipment offsite.

5.2.1 Onsite Operations

The Onsite Operations Department was organized into five sections (91):

- Dosimetry and Records
- Monitoring
- Plotting and Briefing
- Personnel Decontamination
- Vehicle Decontamination.

Members of these sections were responsible for all onsite radiological safety activities. Specifically, they were to (91; 134):

- Provide test participants with film badges and pocket dosimeters
- Provide radiation monitors for test group projects
- Conduct initial radiation surveys and delineate radiation areas in the field by marking the 0.01, 0.1, 1.0, and 10.0 R/h isointensity lines
- Maintain onsite radiation intensity maps
- Brief recovery personnel on radiological conditions in the shot area before recovery operations
- Control access into radiation areas
- Monitor and decontaminate personnel, vehicles, and equipment returning from radiation areas
- Process film badges and maintain film badge exposure records.

Dosimetry and Records

For Shots ABLE, BAKER, CHARLIE, and DOG, the onsite unit of the Logistics and Materiel Department supervised the Dosimetry and Records Section. On 3 May 1952, the Dosimetry and Records Section was transferred from the Logistics and Materiel Department to the Onsite Operations Department (91).

The Dosimetry and Records Section was to provide a DuPont Type 558 film badge and one or more self-reading pocket dosimeters to official reentry parties and other personnel entering a controlled radiation area (an area with radiation intensities exceeding 0.01 R/h). Section personnel processed film badges for all test participants, including Desert Rock personnel (91; 134).

The Onsite Operations Officer determined daily requirements for film badges and pocket dosimeters for the groups taking part in the tests. A dosimetry clerk recorded the name, rank, service number (if appropriate), organization, and project affiliation of each participant in the group. He entered the data onto Form R101, the Daily Record of Radiation Exposure. This form, filled out in duplicate, listed the film badge number by the name of each individual using the device.

The dosimetry clerk issued the duplicate copy of Form R101, together with the film badges and pocket dosimeters, to the monitor accompanying the party, or to the party leader if a monitor was not required. The Dosimetry and Records Section retained the original copy of Form R101 pending return of the dosimeters. Upon completion of the mission, the monitor or party leader collected the dosimeters and returned them and the copy of Form R101 to the clerk at the Dosimetry and Records Section.

Film badges were sent along with Form R101 to the film badge processing laboratory in the Radiological Safety Building at the

Control Point. The film badges were processed by 0800 hours on the following day. After developing the badges, members of the Dosimetry Section determined the net optical density, or darkness, of the film. Using a standard calibration curve, they then determined the radiation exposure indicated by various film densities. Dosimetry personnel entered the density reading and the exposure reading on Form R101.

In addition to Form R101, the Dosimetry and Records Section maintained Form R102, Individual Accumulated Radiation Exposure Record, as a permanent record of cumulative individual exposure. At the completion of the daily dosimeter processing, members of the Dosimetry and Records Section transferred information from Form R101 to Form R102. They sent cumulative exposure records for each individual to the Radiological Safety Director. The names of individuals who had accumulated more than 2.0 roentgens of gamma radiation exposure were underscored (91; 134). At the end of Operation TUMBLER-SNAPPER, the Dosimetry and Records Section compiled the records of individual total exposures into a report (22; 91).

Monitoring

The Monitoring Section performed the daily monitoring assignments required by the Onsite Operations Officer. These assignments included (91; 134):

- Conducting initial ground surveys of shot areas
- Posting signs warning of radiation areas
- Operating checkpoints
- Accompanying program and project personnel into areas with radiation intensities greater than 0.1 R/h.

Monitors conducted initial ground surveys soon after each detonation, beginning from several minutes to almost an hour

after shot-time. The initial survey party, probably four or five two-man teams, traveled in radio-equipped vehicles to the shot area where they took radiation intensity readings. Beginning with Shot BAKER, these readings were taken along stake lines already laid out at the eight major compass headings from ground zero. Monitoring teams moved inward along the stake lines toward ground zero, taking radiation intensity readings at 90-meter intervals until they reached an intensity of 10.0 R/h. The monitors radioed information on the radiation intensity, location, and time to personnel in the Plotting and Briefing Section, who then drew radiation isointensity contour maps. The monitoring teams usually resurveyed the shot area on several days after the detonation. Occasional variations of these procedures are indicated in the discussions of monitoring within the TUMBLER-SNAPPER multi-shot volumes.

The sign-posting detail, consisting of one officer and four enlisted men, posted signs and placed road barricades in radiation areas as directed by the Onsite Operations Officer. Members of the detail placed signs daily on barricades delineating the 0.01 R/h lines on all main and secondary access roads. This detail was also responsible for positioning signs on the 0.1 R/h isointensity line.

Checkpoint monitors were responsible for ensuring that each party entering a controlled area had a properly authorized area access clearance form issued by the Onsite Operations Office. The checkpoint monitors made sure that the names and numbers of individuals in the party and its protective equipment agreed with the entries on the form. If the form was filled in correctly, the monitor entered the time of entry on the document and returned it to the party proceeding into the forward area. When the party returned to the checkpoint, the monitor filled in the exit time and submitted the form on that day to the Onsite Operations Office, where the documents were filed (33; 91).

In addition to processing area access forms, the checkpoint monitors surveyed personnel and their equipment with Beckman MX-5 survey meters and provided the party with brooms to sweep dust from themselves and the equipment. The primary purpose of this preliminary decontamination was to prevent contaminated dust from accumulating on personnel (91; 134).

Plotting and Briefing

The duties of the Plotting and Briefing Section included plotting radiological situation maps based upon information provided by survey parties. Members of this section, who worked in the Plotting and Briefing Room of the Radiological Safety Building, developed maps showing the location of 0.01, 0.1, 1.0, and 10.0 R/h isointensity areas. They updated these maps daily, or as often as resurveys were conducted. The Radiological Safety Director received up-to-date copies of these maps.

A member of this section briefed the leader and monitor of each party before that party entered a controlled radiation area. The briefing included an explanation of the radiological conditions in the area, of the location of checkpoints, and of the radiological safety regulations for radiation areas. After completing his presentation, the individual who had given the briefing signed the area access clearance form for the party and gave the form to the party monitor or leader (91; 134).

Personnel Decontamination

The Personnel Decontamination Section was responsible for monitoring and, if necessary, decontaminating individuals returning from radiation areas. One monitor, positioned outside the entrance to the Personnel Decontamination Section, directed all individuals to remove tape, booties, and gloves, in that order, and to put them in designated receptacles. All gloves and booties were considered contaminated without monitoring. Next, two monitors with Beckman MX-5 portable survey instruments

surveyed personnel in the checkroom, as shown in figure 5-3. Outer garments and equipment registering radiation levels in excess of 0.007 R/h of gamma radiation, or undergarments and external respirator surfaces registering levels in excess of 0.002 R/h of beta and gamma radiation, measured about five centimeters from surfaces, were turned in to a member of the Supply Section. After this check, personnel took showers. One monitor was stationed at the shower exit to check skin contamination. Personnel showing radiation intensities in excess of 0.002 R/h returned to the showers (91; 134).

Vehicle Decontamination

The Vehicle Decontamination Section was responsible for monitoring and decontaminating equipment and vehicles returning from contaminated areas. Vehicles and equipment leaving the test area were stopped and monitored for contamination at checkpoints. Vehicles and equipment registering less than 1,000 counts per minute of alpha contamination per 55 square centimeters, less than 0.002 R/h of gamma radiation outside, and less than 0.002 R/h of gamma plus beta radiation inside passed through the checkpoints. Vehicles and equipment exceeding these radiation levels were sent to the decontamination station (91; 134).

Decontamination consisted initially of washing the contaminated item with steam and hot soapy water on a ramp and allowing it to drain. Personnel monitored the vehicle or equipment after it was washed to determine whether the decontamination was successful. If the radiation intensities had not been reduced to less than 0.002 R/h, the washing and monitoring procedure was repeated until the contamination was reduced to the desired level. If contamination could not be reduced after five or six washings, the vehicle or equipment was placed in a "hot park" adjacent to the decontamination building until radioactive decay reduced contamination to an acceptable level. The hot park was supervised by decontamination personnel, and vehicles or

Figure 5-3: MONITORS SURVEY PERSONNEL RETURNING FROM THE FORWARD AREA

equipment could not be removed without approval of the Vehicle Decontamination Section Officer. Personnel periodically monitored vehicles and equipment in the hot park, and when the radiation intensities had decayed to less than 0.002 R/h, the vehicles and equipment were returned to service (91; 134).

5.2.2 Offsite Operations

The Offsite Operations Department consisted of about ten officers and 50 enlisted men. Under the command of the Offsite Operations Officer, this department was responsible for radiological safety within 320 kilometers of the Nevada Proving Ground. The main function of the Offsite Operations Department was collating reports from aerial radiological surveys and offsite ground surveys in order to prepare maps showing offsite radiological conditions. Personnel assigned to this department also measured the airborne and surface concentration of radioactivity in various areas and determined the offsite fallout pattern (91; 134).

The department consisted of the following subsections:

- Ground Surveys
- Aerial Surveys
- Fallout Measurements
- Radiation Safety Information Center.

Monitoring teams in vehicles conducted ground surveys up to 100 kilometers from the NPG. The two-man mobile teams, who were in radio contact with the Radiation Safety Information Center, varied in number at the shots from eight to 13.

Aerial surveys consisted of cloud tracking and terrain surveys, both of which are discussed in chapter 4 of this volume. B-25 and B-29 aircraft tracked the cloud resulting from the detonation at various altitudes by flying as close to the cloud

as possible without exceeding radiation intensities of 0.002 to 0.005 R/h. Monitors in C-47 and L-20 aircraft conducted aerial surveys of the terrain at heights of 500 to 1,000 feet. These surveys were used to delineate the offsite fallout pattern.

Other offsite personnel operated air-sampling and fallout stations. Approximately 18 of these stations, located from 30 to 320 kilometers from the NPG, were operated for at least 24 hours after each detonation.

Finally, one officer and six non-commissioned officers operated the Radiation Safety Information Center at the Control Point. Information from ground and aerial surveys was radioed to the center, where plots were made showing the fallout path and the radiation levels at offsite locations (91; 134).

5.2.3 Logistics and Materiel

The Logistics and Materiel Department furnished the Radiological Safety Group with supplies, equipment, transportation, and communications. This department consisted of the following sections (91; 134):

- Supply
- Radiac Issue and Repair
- Transportation
- Communications.

The Supply Section issued supplies, including protective equipment, on a daily basis.

Personnel in the Radiac Issue and Repair Section issued instruments for detecting beta and gamma radiation. They repaired and calibrated these instruments as needed after use. Personnel in this section were also participants in Project 6.1, Evaluation of Military Radiac Equipment (91; 151).

The Transportation Section operated a 24-hour motor pool, with at least one mechanic on duty at all times. Members of this section, which maintained military vehicles only, kept a daily record of all vehicles dispatched and returned.

The Communications Section operated and maintained the equipment used to radio survey results from the field to the Control Point (91; 134).

5.2.4 Indian Springs Operations

Although this department followed the standard procedures established by the Radiological Safety Group, it operated independently because of the special mission of AFSWC. Details of AFSWC's radiological safety operations are presented in the next section (82; 91; 134).

5.3 RADIATION PROTECTION FOR AIR FORCE SPECIAL WEAPONS CENTER PERSONNEL

During Operation TUMBLER-SNAPPER, the Air Force Special Weapons Center provided two types of air support to the test groups: test air operations and support air operations. The test air operations included all aircraft directly involved in test missions and projects, such as cloud sampling and cloud tracking. Support air operations included all other aircraft not directly involved in these test missions, such as sample couriers.

The radiological safety of air and ground personnel involved in AFSWC test and support operations was the responsibility of the Test Director. He adopted the joint AEC-DOD organization's exposure limit of 3.0 roentgens for the entire operation. Sampling pilots were permitted to receive up to 3.9 roentgens of gamma radiation (82; 91; 134).

The Test Director's Operations Order, dated 2 February 1952, outlined the responsibilities of the Air Force Special Weapons Center and other organizations participating in TUMBLER-SNAPPER. AFSWC was responsible for a number of tasks related to the radiological safety of its personnel, including (134):

- Briefing the air and ground crews on radiation safety precautions
- Providing protective equipment, film badges, dosimeters, and radiac instruments
- Providing monitors trained in radiological safety
- Decontaminating personnel, aircraft, and equipment.

The 4925th Test Group (Atomic) was responsible for radiological safety operations at Indian Springs AFB. Two officers and eight airmen were assigned to radiological safety operations. The officer in charge came from the Radiological Section of the 4925th Test Group (Atomic), and the other personnel came from various squadrons and groups at Kirtland AFB. The eight airmen had the following duties:

- One was responsible for seeing that decontamination procedures were performed safely.
- One operated the decontamination equipment.
- Six doubled as radiological monitors and wash-crew personnel.

The airman responsible for the safety of decontamination activities was trained in the Passive Defense Section of the 34th Air Division. Several of the other airmen had attended a 40-hour course in basic nuclear science (82).

In addition, one man from the supply department distributed the film badges, which were obtained before each shot from the AFSWP Radiological Safety Group at the NPG Control Point. This individual was also responsible for returning the badges to the

AFSWP Radiological Safety Group for processing and then keeping records of film badge exposures after AFSWP returned the results to Indian Springs (82).

The radiological safety office and personnel decontamination center were located in a large quonset hut on the eastern end of the flight line at Indian Springs AFB. These facilities consisted of an office, a supply room, a dressing room, and showers and latrines (82).

At Kirtland AFB, the 4901st Support Wing (Atomic) performed radiological safety activities similar to those at Indian Springs AFB (82).

5.3.1 Briefing

Before each mission, ground and air crews at Kirtland AFB and Indian Springs AFB attended briefings concerning the weather, the mission, and precautions to minimize exposures to radiation while performing the mission. These briefings, given by the 4925th Test Group at Indian Springs and at Kirtland, were usually presented the day before each shot. At the time of the briefings, crews received film badges and pocket dosimeters (8; 82).

5.3.2 Protective Equipment

The primary goal of the AFSWC radiation protection program was to ensure the radiological safety of AFSWC members by minimizing their exposure to radiation. AFSWC developed procedures to minimize exposure to ionizing radiation.

To minimize internal exposure, which occurs primarily through inhalation of radioactive material, AFSWC ground personnel wore respiratory protection devices if they worked in enclosed spaces or in activities resulting in airborne

radioactive material, such as the unloading of cloud samples. Individuals with open cuts could not enter radiation areas unless the cuts were covered. Ground crews wore protective clothing over their regulation clothing while in radiation areas. Proper wear of protective clothing included closing openings in the coveralls with masking tape. Protective clothing included:

- Fatigue suits and caps
- Shoes and boots
- Rubber chemical gloves
- White cotton gloves.

Upon leaving radiation areas, personnel removed this clothing, showered, and put on clean clothing in order to reduce the chances that they would spread contamination (8; 82).

Procedures had been tested during Operations SANDSTONE and RANGER for minimizing the possibility that cloud-sampling crews would inhale airborne radioactive particles. B-29 crews, for instance, operated depressurized aircraft and remained on full oxygen during the entire sampling mission. Although this method was effective, the pilots were uncomfortable in depressurized aircraft. At TUMBLER-SNAPPER, the B-29 samplers were pressurized, with a filtration system added to the air pressurization system of these aircraft (8; 137).

AFSWC personnel entering radiation areas also wore film badges, provided and processed by the AFSWP Radiological Safety Group. After Shot BAKER, when there were indications that some of the film badges were giving erroneous readings, it became the procedure to wear two badges, taped side by side. The average of the two readings was recorded (82).

5.3.3 Monitoring and Decontamination

Monitors at both Kirtland AFB and Indian Springs AFB used portable radiation detection instruments to check for radioactive

contamination on personnel and aircraft. The radiation detection instruments used at Indian Springs AFB included:

- AN/PDR-T1B ion chamber
- AN/PDR-23 ion chamber
- Beckman MX-5 beta-gamma survey meter
- Electronic integrating ion chamber dosimeter
- Pocket dosimeters with ranges of 0-0.002 roentgens, 0-1 roentgen, 0-5 roentgens, and 0-10 roentgens.

The assessment of contamination levels was an important step in establishing controlled areas and in determining whether procedures had been successful (8; 82). To prevent the spread of contamination, and thus reduce personnel exposure to radiation, AFSWC developed special contamination control procedures for aircrews, groundcrews, and aircraft. These procedures are explained below.

Personnel

AFSWC ground personnel planning to enter radiation areas obtained protective clothing, film badges, and dosimeters from the radiological safety section. Monitors accompanied individuals working in radiation areas. On leaving the radiation areas, personnel were monitored. If radiation intensities greater than 0.002 R/h of gamma radiation were detected after participants had removed their protective clothing, the personnel showered to reduce the intensities and then put on clean clothing (8; 82).

Aircraft

After landing, aircraft taxied to a designated decontamination area. There they were met by radiological monitors, who surveyed the aircraft to determine the level of radioactive contamination. Figure 5-4 shows monitors practicing aircraft survey techniques (9).

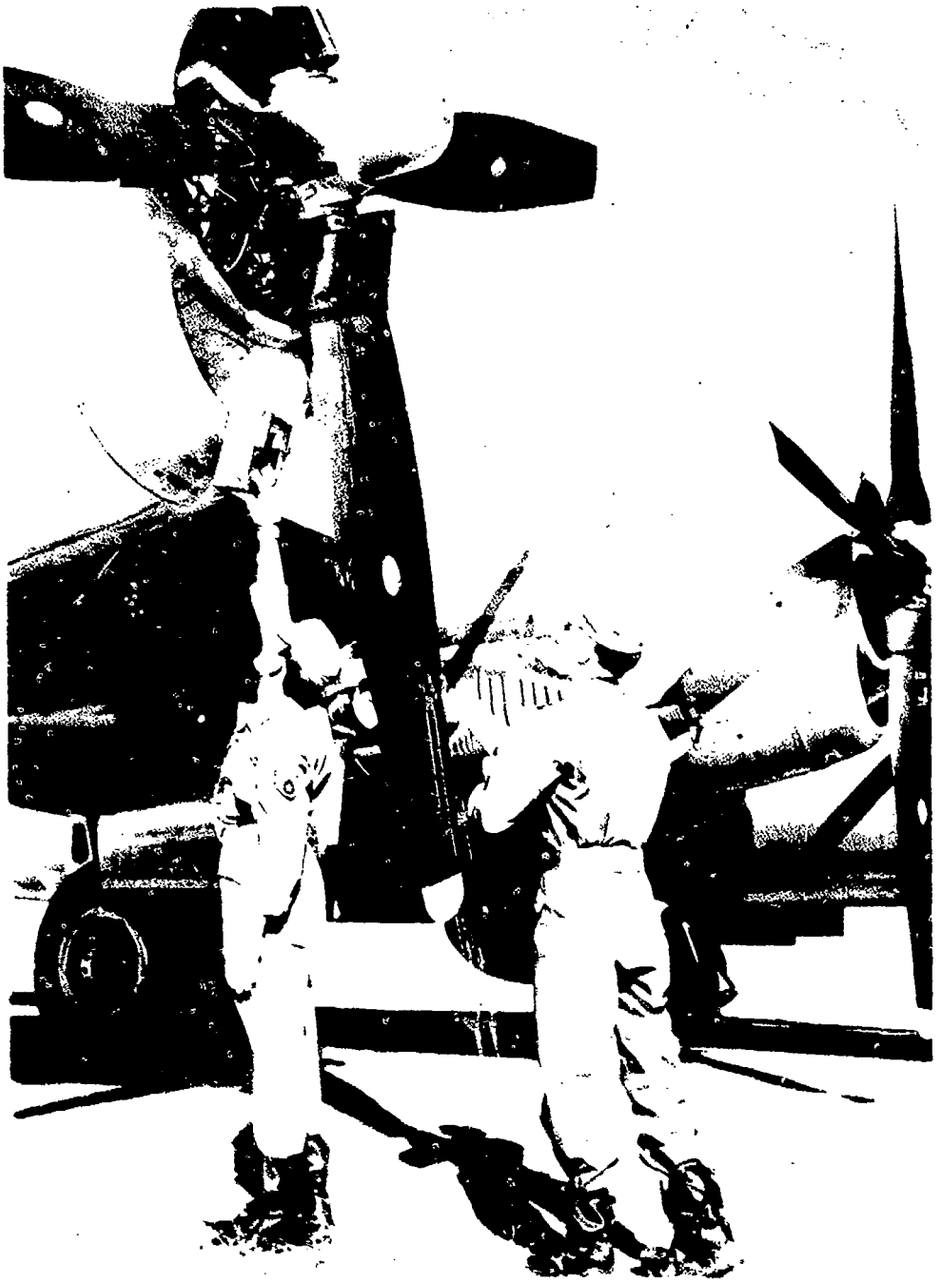

Figure 5-4: MONITORS REHEARSE AIRCRAFT SURVEY TECHNIQUES

Aircraft with gamma radiation intensities of 0.02 R/h and greater were decontaminated by a special cleaning procedure. B-29 aircraft used in the early phase of Operation TUMBLER-SNAPPER were first sprayed with a cleaning compound known as "gunk." The wash crew then rinsed the aircraft's surface with cold water. Later in the test series, a steam generator became available, and the aircraft were first sprayed with steam containing a cleaning compound and then rinsed with cold water. B-29 engines were sprayed with gunk and flushed with cold water. The wash crews used a similar procedure to decontaminate T-33s. For F-84 aircraft, only the surface was sprayed with gunk, steam, and cold water; no attempt was made to clean the engine. If repeated washings did not reduce radiation intensities to acceptable levels, the aircraft were parked in "hot parks" and marked with radiation signs while the radioactivity was allowed to decay. Figure 5-5 pictures a member of the decontamination crew washing a T-33 cloud sampler (9).

A study of sampling aircraft decontamination was conducted as Project 6.5, Decontamination of Aircraft, discussed in chapter 4 of this volume. Radiation monitors were present during all phases of the decontamination, and decontamination crew members wore protective clothing, film badges, and pocket dosimeters (8; 82; 156).

Special procedures were developed for the removal of cloud samples from sampling aircraft. These procedures were designed to prevent personnel from contacting contaminated surfaces. To avoid direct contact with the samples, members of the filter removal team removed the particulate samples from the wing-tip chambers with long-handled tools, as shown in figure 5-6. Before the samples were placed in lead-shielded containers, members of the AFSWC Radiological Safety Group monitored the intensity of the samples, as shown in figure 5-7. Courier aircraft took the samples to laboratories for analysis. Samples were packaged in

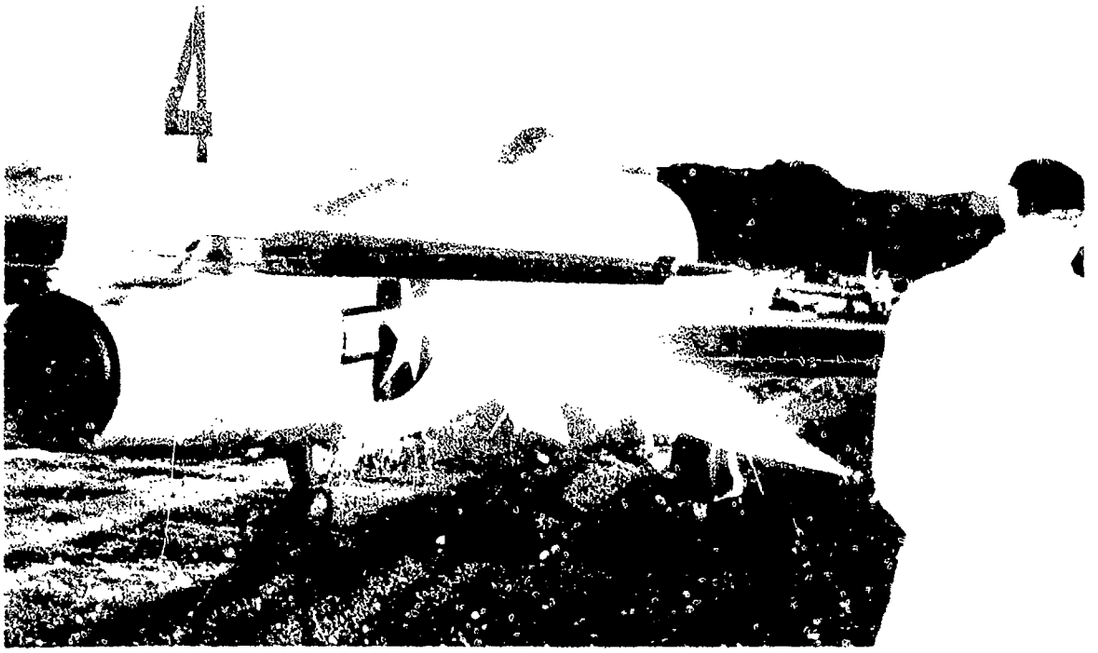

Figure 5-5: MEMBER OF THE DECONTAMINATION CREW PRACTICES AIRCRAFT WASHING TECHNIQUE

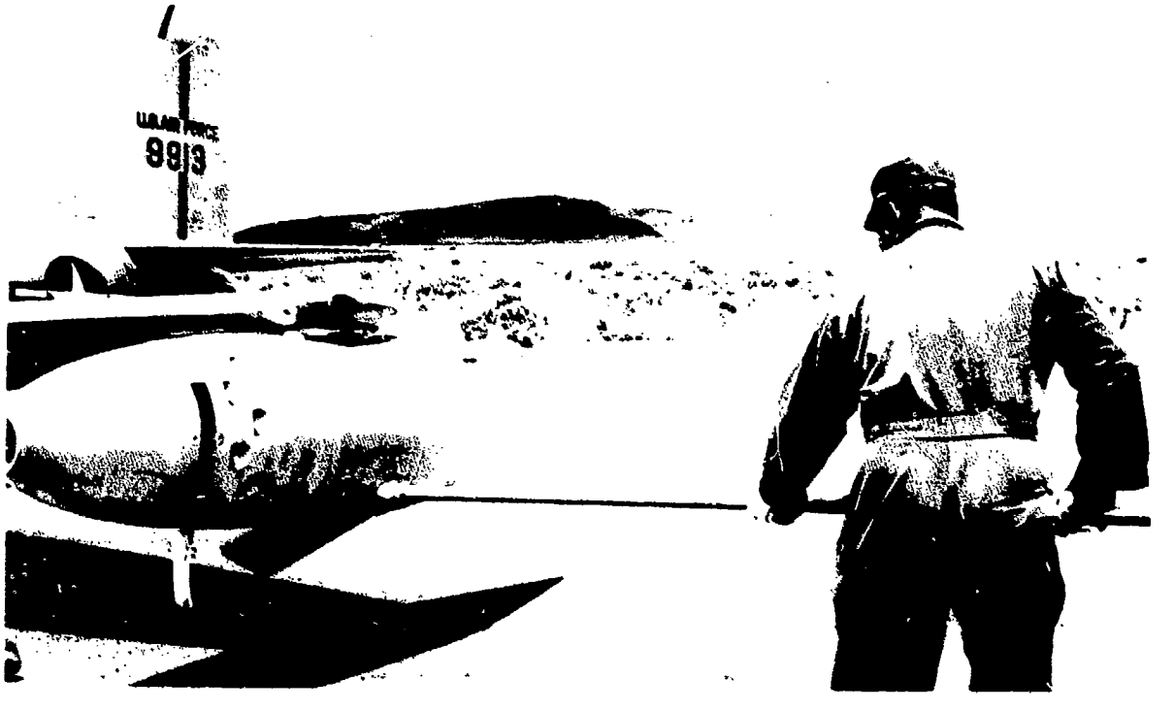

Figure 5-6: MEMBER OF THE SAMPLE REMOVAL TEAM REHEARSES TECHNIQUE USED IN REMOVING WING-TIP CLOUD SAMPLES

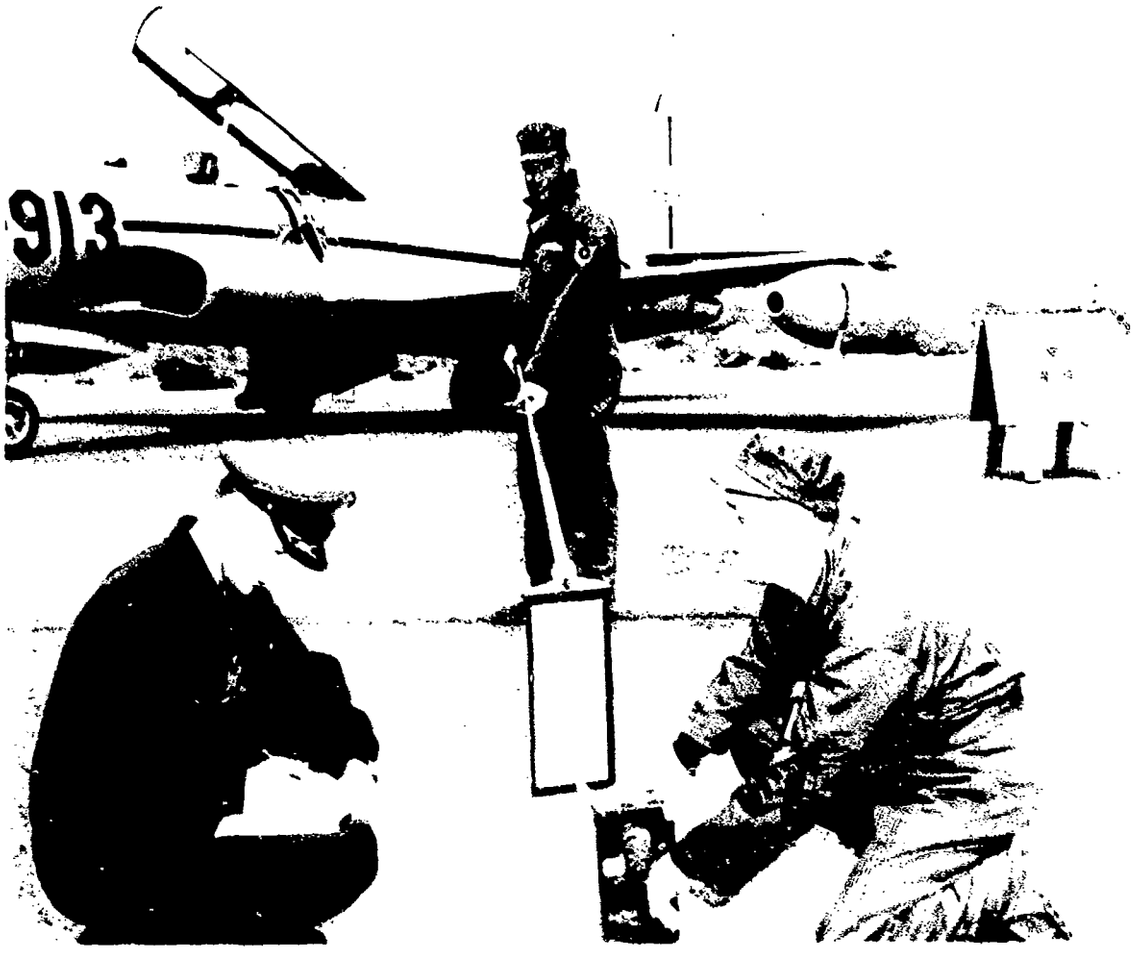

Figure 5-7: AFSWC RADIOLOGICAL SAFETY COORDINATOR AND OTHER MEMBERS OF THE AFSWC RADIOLOGICAL SAFETY GROUP DEMONSTRATE THE TECHNIQUE USED TO MONITOR THE RADIATION INTENSITY OF CLOUD SAMPLES

lead shielding sufficient to ensure that personnel in the courier aircraft would not be exposed to radiation intensities exceeding 0.02 R/h (8; 9; 82).

CHAPTER 6

DOSIMETRY FOR DEPARTMENT OF DEFENSE PERSONNEL AT OPERATION TUMBLER-SNAPPER

This chapter summarizes the data available as of June 1982 regarding the radiation doses received by Department of Defense personnel during their participation in various military and scientific activities during Operation TUMBLER-SNAPPER. It is based on research that identified the participants, their unit or organizational assignment, and their doses.

6.1 PARTICIPATION DATA

The identity of participants was determined from several sources:

- Report of Exercise Desert Rock IV: April-June 1952 provided information on unit participation and activities of Desert Rock organizations (108).
- Weapons test reports for AFSWP and other scientific projects often identified personnel, units, and organizations that participated in the operation.
- After-action reports, security rosters, and vehicle-loading rosters related to the military exercises identified some participants.
- Morning reports, unit diaries, and muster rolls identified personnel assigned to participating units, absent from their home unit, or in transit for the purpose of participating in a nuclear weapons test.
- Official travel or reassignment orders provided information on the identity of transient or assigned personnel participating in the nuclear weapons tests.
- Discharge records, maintained by all services, aided in identification.

- The exposure report of the AFSWP Radiological Safety Group listed the names, units, and total gamma doses for joint AEC-DOD participants at TUMBLER-SNAPPER (22).

- A widely publicized national call-in campaign sponsored by the Department of Defense has identified some of the nuclear weapons test participants.

6.2 SOURCES OF DOSIMETRY DATA

Most of the dosimetry data for Operation TUMBLER-SNAPPER were derived from film badge records. As stated in chapter 5, the AFSWP Radiological Safety Group maintained dosimetry records for each participant.

During Operation TUMBLER-SNAPPER, the film badge was the primary device used to measure the radiation dose received by individual participants. The film badge, normally worn at chest level on the outside of clothing, was designed to measure the wearer's exposure to gamma radiation from external sources. The film badge was insensitive, however, to neutron radiation and did not measure the amount of radioactive material, if any, that may have been inhaled or ingested.

Radiological safety personnel issued, received, developed, and interpreted film badges during Operation TUMBLER-SNAPPER. They recorded film badge data manually, maintaining a dosimetry record for each participant. At the conclusion of the operation, all dose records for Desert Rock participants and all records indicating overexposure for AFSWP and scientific personnel were forwarded to their home stations. When the individual left the service, his records were retired to a Federal records repository (91; 108).

The film badge data summarized in this chapter were obtained from the following sources:

- Historical files of the Reynolds Electrical and Engineering Company, the prime support contractor to the Department of Energy (and previously to the AEC Nevada Operations Office). REECo has provided support at the Nevada Test Site since 1952. REECo assumed responsibility for onsite radiological safety after Operation TEAPOT in July 1955 and subsequently collected available dosimetry records for nuclear test participants at all nuclear testing operations from 1945 to the present. REECo has on microfilm the available exposure records for individuals working under the joint AEC-DOD organization at Operation TUMBLER-SNAPPER.

- Military medical records, maintained at the National Personnel Records Center, St. Louis, Missouri, for troops separated from military service, or at the Veterans Administration, for individuals who have filed for disability compensation or health benefits. Unfortunately, many records were destroyed in a fire at the St. Louis repository in July 1973. That fire destroyed 13 to 17 million Army records for personnel discharged through 31 December 1959 and for members of the Army Air Corps/Air Force discharged through 31 December 1963.

- The radiological safety report for Operation TUMBLER-SNAPPER, which provides some information on participants who received gamma exposures (91).

- A list provided by REECo that gives the total exposures and units or home organization of many of the joint AEC-DOD organization personnel at TUMBLER-SNAPPER (142).

- The exposure report of the AFSWP Radiological Safety Group that lists the names, units, and total gamma doses for joint AEC-DOD participants at TUMBLER-SNAPPER (22).

6.3 DOSIMETRY DATA FOR OPERATION TUMBLER-SNAPPER PARTICIPANTS

This section presents data on the external gamma radiation exposures received by AEC-DOD participants in Operation TUMBLER-SNAPPER.

6.3.1 Format of Dosimetry Data

Tables 6-1 through 6-6 present dosimetry data, organized by service or unit. This information includes:

- The number of personnel identified by name
- The number of personnel identified by both name and film badge
- The average gamma exposure in roentgens
- The distribution of these exposures.

Table 6-1 summarizes all exposures for each service affiliation. In addition to the Army, Navy, Marine Corps, and Air Force designations, the table has information on scientific personnel, contractors, and affiliates. Tables 6-2 through 6-6 provide information about the gamma exposures received by the various participants. In these tables, distributions and averages are given by unit, home station, or organization. For a unit or organization to be represented in the tables, it must meet at least one of the following criteria:

- Records are available for ten or more individuals from the unit.
- At least one individual in the unit had a gamma exposure of 1.0 roentgen or more.

Units not meeting these criteria are consolidated in tables 6-2 through 6-6 in the "other" category, and a distribution of total exposures with an average is provided for them. Tables 6-2a through 6-6a list the individual units that constitute the "other" category in tables 6-2 through 6-6 (72). The individual film badge records summarized in tables 6-6 and 6-6a are for civilians employed either directly or indirectly by the Department of Defense. In most cases, the records contained information on the project on which the individual worked but not on the organization by which he was employed. Hence, the organizations that fielded the projects have been researched and are included in the table.

6.3.2 Instances of Gamma Exposure Exceeding Established Limits

As stated in chapter 5, the gamma exposure limit for participants at TUMBLER-SNAPPER was 3.0 roentgens (108). Cloud sampling pilots, however, were authorized to receive exposures up to 3.9 roentgens (82). Table 6-7 lists the units or organizations that included AEC-DOD personnel who received gamma exposures in excess of the established limits (22; 72; 142).

Several of the overexposed personnel listed in table 6-7 participated in Military Effects Test Group projects that required them to enter radiation areas to retrieve instruments and records. Some of these projects, with their fielding organizations, are:

- Project 2.1 (Signal Corps Engineering Laboratories)
- Project 6.1 (Bureau of Ships; Signal Corps Engineering Laboratories)
- Project 17.1 (Los Alamos Scientific Laboratory).

In addition, research indicates that the individual from the Army Chemical Center participated in Project 1.9, "Pre-shock Dust," and that the participant from the Engineer Research and Development Laboratories took part in Project 3.4, "Minefield Clearance."

Overexposures resulted from a variety of activities. For example, most personnel entered the test area at recovery hour or when permitted by the Test Manager, but personnel from Projects 1.9, 2.1, and 17.1 were permitted to enter the shot area before recovery hour because immediate recovery of equipment or data was necessary to ensure accurate results. Personnel from Project 3.4 inspected, recovered, and replaced land mines that had been placed around ground zero before the shot. To complete these activities, personnel may have spent considerable time in radiation areas. Project 6.1 personnel tested various radiac instruments and survey techniques under field conditions, which

required them to enter radiation areas (22; 46; 72; 92; 116; 138; 142; 143; 151).

Members of the Radiological Safety Group provided radiological safety monitors for all shots. These monitors accompanied AFSWP project personnel on many of the recovery missions. In addition, radiological safety personnel surveyed the shot area after each detonation and manned the checkpoints to the radiation areas. Members of the Radiological Safety Group spent more time in or near radiation areas than other personnel, especially because they repeated their activities during several shots. Personnel from the following units were members of the Radiological Safety Group at TUMBLER-SNAPPER (91):

- AFSWP Test Command
- Carswell AFB, Texas
- Naval Air Station, North Island, California
- 216th Chemical Service Company.

The 4925th Test Group gathered radioactive samples from the clouds resulting from the detonations for analysis by personnel from various test projects. Because this task required the pilots to fly near or through the clouds, their potential exposures were increased (82; 88).

Documentation of the activities of the representatives from the Headquarters of the Armed Forces Special Weapons Project, Fort Belvoir, Fort McClellan, Indian Springs AFB, and the 1009th Special Weapons Squadron was not found.

Table 6-1: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR OPERATION TUMBLER-SNAPPER PARTICIPANTS BY AFFILIATION

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Army	1786	843	.396	295	463	61	17	7
Navy	493	130	.594	51	51	26	2	0
Marine Corps	1980	25	.070	22	2	1	0	0
Air Force	416	416	.497	177	184	36	17	2
Scientific Personnel, Contractors, and Affiliates	389	389	.575	206	98	72	12	1
TOTAL	5064	1803	.468	751	798	196	48	10

Table 6-2: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR ARMY PERSONNEL AND AFFILIATES, OPERATION TUMBLER-SNAPPER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Antiaircraft Artillery Detachment (Provisional)	11	0						
Army Chemical Center	3	2	2.483	0	0	1	1	0
Desert Rock IV	729	729	0.153	288	432	9	0	0
Edgewood Arsenal	3	3	1.949	0	0	3	0	0
Engineer Research and Development Laboratories	1	1	5.930	0	0	0	0	1
Fort Belvoir, VA	13	12	3.327	1	2	2	4	3
Fort McClellan, AL	4	4	4.613	0	0	2	1	1
Fort Monmouth, NJ	3	2	2.641	0	0	2	0	0
Observers	10	1	0.024	1	0	0	0	0
Radiation Safety	1	1	3.440	0	0	0	1	0
Sixth Army	54	0						
Sixth Army Special Field Chemical, Radiological and Biological School	47	0						
1st Armored Division	24	0						
1st Armored Division, 701st Armored Infantry Battalion	54	0						
11th Airborne Division	13	0						
16th Signal Operations Battalion	13	0						
31st Infantry Division (Dixie Division), Camp Atterbury, IN	16	0						
47th Infantry Division	35	0						
82nd Airborne Division	96	0						
218th Chemical Service Company	74	74	1.840	5	15	42	10	2
369th Engineer Amphibious Support Regiment	57	3	0.157	0	3	0	0	0
Other*	449	5	0.195	0	5	0	0	0
Unit Unknown**	126	6	0.105	0	6	0	0	0
TOTAL	1336	943	.396	295	483	61	17	7

* For list of units in this category, see table 6-2a

** Unit information unavailable

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER

Numbered Units

First Army, Battalion (sic)*
First Army, G-4 Headquarters [Governors Island, NY]**
First Army, Provisional
Second Army, Fort Meade, MD
Third Army, Fort McPherson, GA
Third Army, Antiaircraft Artillery Training Center [Camp Stewart, GA]
Fifth Army, Chicago, IL

III Corps Artillery, Fort MacArthur, CA
VI Corps, Headquarters, G-3 Section [Camp Atterbury, IN]
XVIII Airborne Corps, Artillery, Fort Bragg, NC

1st Cavalry, [29th] Antiaircraft Gun Battalion [Chitose, Japan]
1st Composite Group [Provisional], Headquarters Detachment, Fort Bliss, TX
1st Division, Fort Hood, TX (sic)
1st Heavy Artillery Support Group [Sandia Base, NM]
1st MA Division (sic)
1st Missile Group, TX (sic)
1st Training Battalion, Battery "A" (sic)
2nd Armored Division, Fort Hood, TX [Bad Kreunsach, Germany]
2nd Signal Photography, Camp Mercury, NV
3rd Armored Cavalry [Regiment], Camp Pickett, VA
3rd Armored Cavalry, Company "B"
3rd Infantry Division [Korea]
3rd Infantry Regiment, Washington, DC
3rd Provisional Detachment, Fort Hood, TX
4th Armored Division (sic) [Activated 15 June 1954 at Fort Hood, TX]***
5th Armored Division, Fort Chaffee, AR
5th Infantry Division [Indiantown Gap, PA]

6th Armored Field Artillery Battalion, Fort Sill, OK
6th Infantry Division, Fort Ord, CA

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*"Sic" indicates that the table entry for the unit and/or home station appears as it was listed in source documentation.

**Unit and/or home station verification based on the "Directory and Station List of the US Army" for April 1952 and June 1952. Additional information from the Station List is provided in brackets.

***Unit files in Organizational History Branch, Office Chief of Military History.

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER (Continued)

6th Signal Corps (sic)
6th Transportation Company (Helicopter) [Fort Hood, TX]
8th Infantry Division, Fort Jackson, SC
8th Trng, Fort Belvoir, VA (sic)
9th Ordnance Battalion, Sandia Base, NM
9th Antiaircraft Artillery Group [Fukuoka, Japan]
10th Infantry Division, Fort Riley, KA
10th Special Forces Group, Fort Bragg, NC

11th Airborne Infantry Division, Fort Campbell, KY
13th Infantry Division, Headquarters (sic)
15th Signal Operations Company [Camp San Louis Obispo, CA]
16th Armored Engineer Battalion, Fort Hood, TX
17th Chemical Technical Intelligence Company [Rocky Mountain Arsenal, Denver, CO]
19th Engineer Battalion, Company "B", Fort Meade, MD
19th Infantry [Regiment], Company "I" [Sendai, Japan]

21st Engineer Brigade (sic)
21st Engineer Combat Battalion, Camp Carson, CO
23rd Transportation Truck Company, Camp Roberts, CA
24th Antiaircraft Artillery Group [Fort Dix, NJ]
24th Evacuation Field Hospital, Fort Benning, GA
24th Infantry Division, 52nd Field Artillery Battalion [Sendai, Japan]
25th Armored Infantry Battalion, Fort Hood, TX

26th Transportation [Truck] Battalion [Fort Hood, TX]
27th Regimental Combat Team [25th Infantry Division, Chunchon, Korea]
28th Transportation Truck Company [Taegu, Korea]
29th Ordnance Battalion, Fort Bragg, NC
30th Combat Training Company (sic)
30th Infantry Regimental Combat Team [Fort Benning, GA]
30th Infantry Reg Volunteer CBR of (sic)

31st Transportation Company [Camp Roberts, CA]
32nd Division (sic)
37th Infantry Division, Camp/Fort Polk, LA
38th Transportation Truck Company
39th Engineer [Construction] Group [Ettlingen, Germany]

42nd Morter, Fort Benning, GA (sic)
43rd Truck Company [Yongdung po, Korea]
44th Infantry Division, Camp Cooke, CA
47th Medical Battalion [Fort Hood, TX]
48th Infantry, 37th Division (sic)
49th Antiaircraft Artillery Gun Battalion, Battery "C"
49th Infantry (sic)

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER (Continued)

50th Chemical Maintenance Platoon (sic) [505th Chemical Maintenance Company, Fort Bragg, NC]
52nd Antiaircraft Gun Battalion (sic)
52nd Division, AA, Camp Roberts, CA (sic)
60th [66th] Signal Battalion [Detachment, Fort Hood, TX]

61st Infantry Training Battalion (sic)
63rd Transportation Truck Company, Headquarters 122nd T (sic)
65th Explosive Ordnance Disposal Squad, 545th Detachment [Fort Devens, MA]
68th Armored Field Artillery Battalion, Fort Hood, TX

73rd Tank Battalion [Chunchon, Korea]
77th Antiaircraft [Artillery Gun] Battalion [Camp Stewart, GA]
77th Army Band [Fort Huachuca, AZ]

81st Chemical Group [Fort Bragg, NC]
87th Infantry Division (sic) [Regiment, Fort Riley, KS]
89th [Antiaircraft Artillery] Gun Battalion, Battery "A" [Fort Meade, MD]

91st [Armored] Field Artillery [Fort Hood, TX]
94th Veterinary Food Inspection Service, Detachment
95th Technical Service Unit (sic)

101st Armored Infantry Battalion (sic)
127th Engineer Combat Battalion, Company "B", Fort Bragg, NC
135th Radiological Warfare ENG (sic)
148th Truck Company, Fort Benning, GA

151st Field Artillery, Fort Rucker, AL
154th Signal Battalion (sic)

161st Ordnance Depot Company [Camp Cooke, CA]
161st Supply Company Part OR 393 R (sic)
163rd Military Police Battalion, Company "C" [Fort Hood, TX]
168th Military Police Battalion, Headquarters Company, Fort Meade, MD

231st Engineer Combat Battalion [Fort Lewis, WA]
278th Regimental Combat Team [Camp Drum, NY]

301st Signal Photographic Company [Fort Hood, TX]
303rd Signal Service Battalion [Fort Hood, TX]
313th Signal Construction Battalion [Fort Meade, MD]
314th Signal Construction Battalion, Detachment [San Luis Obispo, CA]
315th Signal Battalion [Worms, Germany]
325th Tank Battalion [Camp Irwin, CA]

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER (Continued)

330th Ordnance Battalion (3rd Armored Cavalry Regiment) [Camp Pickett, VA]

360th Army Band [Fort Worden, WA]
361st Engineer [Construction] Battalion [Fort Leonard Wood, MO]
365th Ordnance [Battalion], Red River Arsenal [TX]
374th Convalescent Center [Garmisch, Germany]
393rd Ordnance [Battalion, Camp Cooke, CA]

405th Medical Detachment (sic)
412th Engineer Construction Battalion [Camp Roberts, CA]
422nd Gun Battalion, Battery "A" (sic)
449th Armored Field Artillery Battalion, Headquarters Company, Fort Bragg, NC

464th Signal Battalion (sic)
466th [Antiaircraft Artillery] Battalion, Camp Cooke, CA
469th National Guard (sic)
484th Engineer Construction Battalion, Headquarters and Service Company [Camp Atterbury, IN]

501st Chemical [Depot Company, Fort McClellan, AL]
503rd Signal Radio Operator Company [San Luis Obispo, CA]
505th Military Police Battalion, Company "A", Camp Roberts, CA
506th Helicopter Company, Fort Benning, GA
508th [Field] Artillery [Battalion], Camp/Fort Polk, LA
508th Regimental Combat Team (Airborne) [Fort Hood, TX]
509P Signal Corps (sic)
510th Armored Infantry (sic) [Battalion activated June 1954, Fort Hood, TX]***
515th Transportation Truck Company [Taegu, Korea]
532nd Engineer Boat and Shore Battalion, Company "D"
538th Field Artillery Battalion, Camp Carson, CO

551st Antiaircraft Artillery Gun Battalion, Camp Stewart (sic)
562nd Transportation Staging Area Company [Camp Stoneman, CA]
576th Transportation [Car] Company [Salzburg, Austria]
597th Engineer Equipment Company [Fort Huachuca, AZ]

601st Antiaircraft Artillery Battalion, Battery "C" (sic)
663rd Unit, Company "B", Fort Bragg, NC (sic)

705th Engineer Field Maintenance [Company, Fort Huachuca, AZ]
710th Antiaircraft Artillery Gun Battalion (sic)
720th Field [Artillery] Battalion [Fort Lewis, WA]
723rd Tank Battalion (sic)
728th Antiaircraft Artillery Gun Battalion [Fort Bliss, TX]

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER (Continued)

752nd Antiaircraft Artillery Gun Battalion, Oakland, CA (sic)
773rd Tank Battalion [Fort Benning, GA]

936th Field Artillery Battalion [Taegu, Korea]
973rd Engineer Construction Battalion, Camp Carson, CO

4005th ASV, Fort Hood, TX (sic)
4005th Medical Detachment, Fort Hood, TX
6002 Area Service Unit (sic)
6003 Area Service Unit, Headquarters Company, Fort Ord, CA (sic)
6006 ASU, Fort Lewis, WA (sic)
6020 ASU, Camp Desert Rock (sic)
9393rd Technical Service Unit, Ordnance Detachment 2 (sic)
9471st Technical Service Unit [Fort Monmouth, NJ]
9771st Technical Service Unit, Dugway Proving Ground (sic) [Toolele, UT]

Department of the Army

Army Corps of Engineers
Assistant Chief of Staff for Intelligence
Deputy Chief of Staff, Operations
Office Chief of Finance
Office Chief of Ordnance
Office of Chief Chemical Corps
Office of Provost Marshal General
Office of Surgeon General
Office Quartermaster General
Research and Development (sic)

Commands

Army Caribbean Command, Canal Zone
Chemical Corps Training Command (sic)
Far East Command, Headquarters, Tokyo, Japan
Missile Command (sic)

Schools

Antiaircraft and Guided Missile Branch of The Artillery School, Fort Bliss, TX
Chemical Corps School, Fort McClellan, AL
Command and General Staff College, Fort Leavenworth, KA
Engineer School, Fort Belvoir, VA
(The) Infantry School, Fort Benning, GA

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER (Continued)

Medical Field Service School, Fort Sam Houston, TX
Medical Training Center, Camp Pickett, VA
Military Police Replacement Training Center [Camp Gordon, GA]
Ordnance School, Aberdeen Proving Ground, MD
Southeastern Signal School, Fort Gordon, GA
Southwestern Signal School, Camp San Louis Obispo, CA

Locations

Aberdeen Proving Ground, MD
Camp Cooke, CA
Camp Drum, NY
Camp Mercury, NV
Camp Pickett, VA
Camp/Fort Polk, LA
Camp Roberts, CA
Ent Air Force Base, CO
Fort Bliss, TX
Fort Bragg, NC
Camp Carson, CO
Fort Dix, NJ
Fort Eustis, VA
Fort Hood, TX
Fort Jackson, SC
Fort Knox, KY
Fort Lawton, WA
Fort McNair, Washington, DC
Fort Ord, CA
Fort Riley, KA
Fort Worden, WA
Redstone Arsenal, AL

Miscellaneous

Armed Forces Special Weapons Project, Sandia Base, NM
Army Medical Corps, Headquarters Detachment
Army Medical Service
Army Pictorial Center
Control Group Alpha (sic)
Dept Combined Arms Special Weapons (sic)
Engineer Provisional Company (sic)
Engineer Unit, Fort Wagner, WA (sic)
Hunters Point Battery DOG, San Francisco (sic)
Joint Chiefs of Staff
Joint Task Force 132, TG1322 (sic)
Medical Corps at Test (sic)

Table 6-2a: DETAILED LISTING OF "OTHER" CATEGORY, ARMY PARTICIPANTS, OPERATION TUMBLER-SNAPPER (Continued)

Office Chief Army Field Forces, Fort Monroe, VA
Ordnance Board [Aberdeen Proving Ground, MD]
Quartermaster Research and Development, Fort Lee, VA
Radiation Safety
ROTC of A&M College (sic)
Separation Unit, Fort Hood, TX
Special Weapons Operation Corps (sic)

Table 6-3: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR NAVY PERSONNEL AND AFFILIATES, OPERATION TUMBLER-SNAPPER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Armed Forces Special Weapons Project	29	12	0.717	7	2	2	1	0
Atomic Energy Commission	3	2	1.535	0	1	1	0	0
Bureau of Ships	3	2	0.950	1	0	1	0	0
Chief of Naval Operations	11	0						
Commander Training Atlantic	2	1	2.670	0	0	1	0	0
Joint Chiefs of Staff	2	1	2.688	0	0	1	0	0
Naval Administrative Unit, Kirtland AFB	11	2	0.255	1	1	0	0	0
Naval Air Station, North Island, CA	1	1	4.215	0	0	0	1	0
Naval Material Laboratory	1	1	1.955	0	0	1	0	0
Naval Medical Research Institute	20	13	0.421	7	3	3	0	0
Naval Ordnance Laboratory	23	9	0.178	3	6	0	0	0
Naval Radiological Defense Laboratory	36	22	0.680	10	6	6	0	0
Naval Research Laboratory	59	38	0.488	11	19	8	0	0
1st Marine Corps Provisional Atomic Exercise Battalion*	68	0						
2d Marine Corps Provisional Atomic Exercise Battalion*	70	1	0.995	0	1	0	0	0
Others**	67	14	0.354	5	9	0	0	0
Unknown***	87	11	0.461	6	3	2	0	0
TOTAL	493	130	0.594	51	51	26	2	0

* Naval support personnel assigned to the Marine Corps.
** For list of units in this category, see table 6-3a.
*** Unit information unavailable.

Table 6-3a: DETAILED LISTING OF "OTHER" CATEGORY, NAVY PARTICIPANTS, OPERATION TUMBLER-SNAPPER

Bureau of Aeronautics
Bureau of Medicine and Surgery
Bureau of Personnel
Civil Effects Test Group
Commandant First Naval District
Commandant Second Fleet
Commandant Third Naval District
Commandant Twelfth Naval District
Commander Amphibious Group 3
Commander Amphibious Pacific
Commander Cruiser Destroyer Pacific
Commander Joint Task Force 132
Commander Naval Air Command Atlantic
Commander Naval Air Command Pacific
Commander Training Pacific
David Taylor Model Basin
Directorate Weapons Effects Test
Joint Air Defense Board
Los Alamos Scientific Laboratory
Military Sea Transport Service
Naval Administrative Unit, Sandia, NM
Naval Attachment, Kirtland AFB, NM
Naval Civil Engineering Research and Evaluation Laboratory
Naval Electronics Laboratory
Naval Schools Command, Treasure Island, CA
Navy Special Weapons Unit 802
Navy Special Weapons Unit 1233
Observers
Operations Development Forces
San Francisco Naval Shipyard

Table 6-4: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR MARINE CORPS PERSONNEL AND AFFILIATES, OPERATION TUMBLER-SNAPPER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<1	1-1.0	1.0-3.0	3.0-5.0	5.0+
1st Marine Corps Provisional Atomic Exercise Brigade	1925	21	0.083	18	2	1	0	0
Other*	13	4	0.000	4	0	0	0	0
Unit Unknown — Observer**	42	0						
TOTAL	1980	25	0.070	22	2	1	0	0

* For list of units in this category, see table 6-4a.
** Unit information unavailable.

Table 6-4a: DETAILED LISTING OF "OTHER" CATEGORY, MARINE CORPS PARTICIPANTS, OPERATION TUMBLER-SNAPPER

Headquarters and Service Battalion, Marine Corps Recruitment Depot, Parris Island, SC--Observer

Headquarters Battalion, Headquarters Marine Corps, Washington, D.C.--Observers

Headquarters Battalion, 2d Marine Division, Fleet Marine Force Atlantic

Headquarters Battalion, 3d Marine Division, Fleet Marine Force Pacific--Observers

Marine Corps School, Quantico, VA--Observer

Service Company, 3d Engineer Battalion, 3d Marine Division, Fleet Marine Force Pacific

Service Company, 8th Tank Battalion, Fleet Marine Force, Camp Lejeune, NC

Staff, Commander, Amphibious Force, US Pacific Fleet

1st Battalion, 3d Marines, 3d Marine Division, Fleet Marine Force Pacific

2d Amphibious Reconnaissance Battalion Fleet Marine Force, Camp Lejeune, NC

2d Battalion, 3d Marines, 3d Marine Division, Fleet Marine Force Pacific

Table 6-5: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR AIR FORCE PERSONNEL AND AFFILIATES, OPERATION TUMBLER-SNAPPER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Carswell AFB	1	1	4.540	0	0	0	1	0
Indian Springs AFB	89	89	0.482	35	40	12	2	0
Lookout Mountain Laboratory	13	13	0.248	4	9	0	0	0
Wright Air Development Center	23	23	0.199	8	15	0	0	0
4925th Test Group	269	269	0.545	117	112	24	14	2
Other*	21	21	0.231	13	8	0	0	0
TOTAL	416	416	0.497	177	184	36	17	2

* For list of units in this category, see table 6-5a

Table 6-5a: DETAILED LISTING OF "OTHER" CATEGORY, AIR FORCE PARTICIPANTS, OPERATION TUMBLER-SNAPPER

Air Research and Development Command, Bolling Air Force Base
Headquarters, Tactical Air Command
Headquarters, United States Air Force, Washington, D.C.
Jangle*
Norton Air Force Base, CA

*These individuals were probably program personnel completing their assignments for Operation BUSTER-JANGLE in March 1952 (91).

Table 6-6: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR SCIENTIFIC PERSONNEL, CONTRACTORS, AND AFFILIATES, OPERATION TUMBLER-SNAPPER

Organizations*	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
AFSWP Test Command	134	134	0.206	106	18	9	1	0
AFSWP Test Command—Radiological Safety	61	61	1.547	9	14	32	5	1
Program 1—Blast Measurement	2	2	0.815	0	1	1	0	0
Program 3—Structures	4	4	0.267	3	0	1	0	0
Program 6—Test of Equipment	2	2	0.811	1	0	1	0	0
Program 9—Support	4	4	0.413	2	1	1	0	0
Project 1.1 (Air Force Cambridge Research Center; Rome Air Development Center)	14	14	0.165	6	8	0	0	0
Project 2.1 (Signal Corps Engineering Laboratories)	2	2	3.784	0	0	0	2	0
Project 2.3 (Naval Research Laboratory)	3	3	0.405	2	0	1	0	0
Project 3.1 (Wright Air Development Center; Naval Radiological Defense Laboratory; Los Alamos Scientific Laboratory)	35	35	0.521	11	18	6	0	0
Project 3.3 (Forest Service)	2	2	0.772	1	0	1	0	0
Project 4.3 (Naval Radiological Defense Laboratory)	7	7	0.301	4	2	1	0	0
Project 6.1 (Bureau of Ships; Signal Corps Engineering Laboratories)	19	19	1.274	3	5	10	1	0
Project 6.7 (Army Chemical Center)	8	8	1.260	0	3	5	0	0
Project 7.4 (Air Force 1009th Special Weapons Squadron)	4	4	1.605	0	2	1	1	0
Project 9.1 (Signal Corps Engineering Laboratories; Naval Medical Research Institute; Lookout Mountain Laboratory; Wright Air Development Center; Army Pictorial Service Division; 4925th Test Group (Atomic); Strategic Air Command 5th and 28th Reconnaissance Technical Squadrons)	13	13	0.136	8	5	0	0	0
Project 17.1 (Los Alamos Scientific Laboratory)	2	2	3.700	0	0	0	2	0
Stanford Research Institute	2	2	0.862	1	0	1	0	0
University of California	6	6	0.484	5	0	1	0	0
Other**	65	65	0.132	44	21	0	0	0
TOTAL	389	389	0.575	206	98	72	12	1

* Individual exposures are listed by name and project in the film badge records. Where two or more organizations fielded a project, the specific organization of participation for an individual cannot be determined.

** For list of units in this category, see table 6-6a.

Table 6-6a: DETAILED LISTING OF "OTHER" CATEGORY, SCIENTIFIC PERSONNEL, CONTRACTORS, AND AFFILIATES, OPERATION TUMBLER-SNAPPER

Armed Forces Special Weapons Project
Armed Forces Special Weapons Project, Headquarters
Boeing Aircraft Company
North American Aviation
Program 2 - Nuclear Measurements
Program 4 - Biomedical
Program 7 - Long Range Detection
Program 8 - Thermal Measurements
Program 914 (sic)*
Project 1.2 (Stanford Research Institute)
Project 1.3 (Naval Ordnance Laboratory)
Project 1.4 (Ballistic Research Laboratories)
Project 1.5 (Naval Ordnance Laboratory)
Project 1.6 (The Johns Hopkins University Applied Physics Laboratory)
Project 1.7 (Stanford Research Institute)
Project 1.13 (David Taylor Model Basin)
Project 2.2 (Signal Corps Engineering Laboratories)
Project 3.4 (Engineer Research and Development Laboratories)
Project 4.2 (Naval Medical Research Institute)
Project 4.4 (Naval Medical Research Institute)
Project 4.5 (Air Force School of Aviation Medicine; Air Training Command; Brooke Army Medical Center; Strategic Air Command)
Project 4.6 (Naval Medical Research Institute; University of Rochester)
Project 5.1 (Desert Rock)
Project 7.1 (Headquarters, Air Force; National Bureau of Standards; Air Force Cambridge Research Center; Air Weather Service; University of California; EG&G)
Project 8.2 (Naval Radiological Defense Laboratory)
Project 8.3 (Naval Radiological Defense Laboratory)
Project 8.5 (Forest Service)
Project 8.6 (Naval Electronics Laboratory)
Project 9.2 (Air Weather Service)

*"Sic" indicates that the table entry for the unit and/or organization appears as it was listed in source documentation.

Table 6-7: FILM BADGE READINGS EXCEEDING ESTABLISHED LIMITS FOR DOD PARTICIPANTS AT TUMBLER-SNAPPER

Unit or Organization	Number of Personnel	Total Exposures (Roentgens)
Armed Forces Special Weapons Project	1	3.2
Armed Forces Special Weapons Project Test Command	7	3.0, 3.0, 3.1, 3.7, 4.2, 4.7, 6.1
Army Chemical Center	1	3.3
Carswell AFB, TX	1	4.5
Engineer Research and Development Laboratories	1	5.9
Fort Belvoir, VA	7	3.5, 3.6, 3.7, 4.8, 5.5, 6.9, 7.0
Fort McClellan, AL	2	3.2, 10.8
Indian Springs AFB, NV	2	3.2, 3.5
Naval Air Station, North Island, CA	1	4.2
Project 2.1 (Signal Corps Engineering Laboratories)	2	3.7, 3.9
Project 6.1 (Bureau of Ships; Signal Corps Engineering Laboratories)*	1	3.1
Project 7.4 (1009th Special Weapons Squadron)	1	3.5
Project 17.1 (Los Alamos Scientific Laboratory)	2	3.5, 3.9
Radiological Safety	1	3.4
216th Chemical Service Company	12	3.3, 3.3, 3.4, 3.4, 3.5, 3.6, 4.0, 4.0, 4.4, 4.9, 6.1, 9.0
4925th Test Group**	8	4.0, 4.1, 4.2, 4.2, 4.3, 4.8, 6.9, 7.6
TOTAL	50	

* Individual exposures are listed by name and project in the film badge records. Where two or more organizations fielded a project, specific organization of participation for an individual cannot be determined.

** Subject to 3.9 roentgen AFSWC limit.

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U.S. Coast Guard Academy Library
ATTN: Library

U.S. House of Representatives
ATTN: Committee on Armed Svcs

OTHER GOVERNMENT AGENCIES (Continued)

U.S. House of Representatives
Committee on Interstate & Foreign Commerce
ATTN: Subcommittee on Health & Envir

U.S. Senate
Committee on Armed Services
ATTN: Committee on Veterans Affairs

U.S. Senate
ATTN: Committee on Veterans Affairs

Veterans Administration-RO
Providence, RI
ATTN: Director

Veterans Administration-RO
Montgomery, AL
ATTN: Director

Veterans Administration-RO
Anchorage, AK
ATTN: Director

Veterans Administration-RO
Phoenix, AZ
ATTN: Director

Veterans Administration-RO
Little Rock, AR
ATTN: Director

Veterans Administration-RO
Los Angeles, CA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
Denver, CO
ATTN: Director

Veterans Administration-RO
Hartford, CT
ATTN: Director

Veterans Administration-RO
Wilmington, DE
ATTN: Director

Veterans Administration-OFC Central
Washington, D. C.
ATTN: Dept Veterans Benefit, Central Ofc
ATTN: Director

Veterans Administration
Washington, D. C.
ATTN: Board of Veteran Appeal

Veterans Administration-RO
St. Petersburg, FL
ATTN: Director

Veterans Administration-RO
Atlanta, GA
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Honolulu, HI
ATTN: Director

Veterans Administration-RO
Chicago, IL
ATTN: Director

Veterans Administration-RO
Seattle, WA
ATTN: Director

Veterans Administration-RO
Indianapolis, IN
ATTN: Director

Veterans Administration-RO
Des Moines, IA
ATTN: Director

Veterans Administration-RO
Wichita, KS
ATTN: Director

Veterans Administration-RO
Louisville, KY
ATTN: Director

Veterans Administration-RO
New Orleans, LA
ATTN: Director

Veterans Administration-RO
Togus, ME
ATTN: Director

Veterans Administration-RO
Baltimore, MD
ATTN: Director

Veterans Administration-RO
Boston, MA
ATTN: Director

Veterans Administration-RO
St. Paul, MN
ATTN: Director

Veterans Administration-RO
Jackson, MS
ATTN: Director

Veterans Administration-RO
Huntington, WV
ATTN: Director

Veterans Administration-RO
St. Louis, MO
ATTN: Director

Veterans Administration-RO
Ft. Harrison, MT
ATTN: Director

National Archives
ATTN: Librn

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Lincoln, NE
ATTN: Director

Veterans Administration-RO
Reno, NV
ATTN: Director

Veterans Administration-RO
Manchester, NH
ATTN: Director

Veterans Administration-RO
Newark, NJ
ATTN: Director

Veterans Administration-RO
Milwaukee, WI
ATTN: Director

Veterans Administration-RO
Albuquerque, NM
ATTN: Director

Veterans Administration-RO
Buffalo, NY
ATTN: Director

Veterans Administration-RO
New York, NY
ATTN: Director

Veterans Administration-RO
Winston-Salem
ATTN: Director

Veterans Administration-RO
Fargo, ND
ATTN: Director

Veterans Administration-RO
Cleveland, OH
ATTN: Director

Veterans Administration-RO
Muskogee, OK
ATTN: Director

Veterans Administration-RO
Portland, OR
ATTN: Director

Veterans Administration-RO
Pittsburgh, PA
ATTN: Director

Veterans Administration-RO
Philadelphia, PA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
San Juan, Puerto Rico
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Columbia, SC
ATTN: Director

Veterans Administration-RO
Sioux Falls, SD
ATTN: Director

Veterans Administration-RO
Houston, TX
ATTN: Director

Veterans Administration-RO
Waco, TX
ATTN: Director

Veterans Administration-RO
Salt Lake City, UT
ATTN: Director

Veterans Administraiton-RO
White River Junction, VT
ATTN: Director

Veterans Administration-RO
Roanoke, VA
ATTN: Director

Veterans Administration-RO
Cheyenne, WY
ATTN: Director

Veterans Administration-RO
San Diego, CA
ATTN: Director

Veterans Administration-RO
Boise, ID
ATTN: Director

Veterans Administration-RO
Detroit, MI
ATTN: Director

Veterans Administration-RO
Nashville, TN
ATTN: Director

The White House
ATTN: Domestic Policy Staff

DEPARTMENT OF ENERGY CONTRACTORS

Lawrence Livermore National Lab
ATTN: Tech Info Dept Library

Los Alamos National Lab
ATTN: Library
2 cys ATTN: ADEA MMS 195

Sandia National Lab
ATTN: M. Perrefort
ATTN: Central Library

Reynolds Electrical & Engr Co., Inc
ATTN: CIC
ATTN: M. Brady

OTHER

Adams State College
ATTN: Librn

Akron Public Library
ATTN: Librn

Alabama State Dept of Archives & History
ATTN: Military Records Div

University of Alabama
ATTN: Reference Dept, Documents

University of Alaska Library at Anchorage
ATTN: Librn

University of Alaska
ATTN: Dir of Libraries

Albany Public Library
ATTN: Librn

Alexander City State Jr College
ATTN: Librn

Allegheny College
ATTN: Librn

Allen County Public Library
ATTN: Librn

Altoona Area Public Library
ATTN: Librn

American Statistics Index
Congressional Info Service, Inc
ATTN: Cathy Jarvey

Anaheim Public Library
ATTN: Librn

College of Wooster
ATTN: Gov Docs

Angelo State University Library
ATTN: Librn

Angelo Jacoboni Public Library
ATTN: Librn

Anoka County Library
ATTN: Librn

Appalachian State University
ATTN: Library Docs

Arizona State University Library
ATTN: Librn

University of Arizona
ATTN: Gov Doc Dept C. Bower

Arkansas College Library
ATTN: Library

Brooklyn College
ATTN: Doc Div

OTHER (Continued)

Arkansas Library Comm
ATTN: Library

Arkansas State University
ATTN: Library

University of Arkansas
ATTN: Gov Docs Div

Austin College
ATTN: Librn

Atlanta Public Library
ATTN: Ivan Allen Dept

Atlanta University
ATTN: Librn

Auburn University Library at Mongomery (Reg)
ATTN: Librn

C. W. Post Ctr Long Island University
ATTN: Librn

Bangor Public Library
ATTN: Librn

Bates College Library
ATTN: Librn

Baylor University Library
ATTN. Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

State University College
ATTN: Gov Docs

Akron University
ATTN. Gov Docs

Boston Public Library (Reg)
ATTN: Docs Dept

Bowdoin College
ATTN: Librn

Bowling Green State University
ATTN: Lib Gov Docs Services

Bradley University
ATTN: Librn

Brandeis University Library
ATTN: Docs Section

Brigham Young University
ATTN: Librn

Brigham Young University
ATTN: Docs Collection

Brookhaven National Laboratory
ATTN: Tech Library

OTHER (Continued)

Broward County Library Sys
ATTN: Librn

Brown University
ATTN: Librn

Bucknell University
ATTN: Reference Dept

Buffalo & Erie Co Public Library
ATTN: Librn

State University Library of California at Fresno
ATTN: Library

University Library of California at Los Angeles
ATTN: Pub Affairs Serv U.S. Docs

University of California at San Diego
ATTN: Docs Dept

State College Library of California at Stanislaus
ATTN: Library

California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Librn

California State University at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Librn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Librn

California University Library
ATTN: Gov Docs Dept

California University Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN: Librn

Kearney State College
ATTN: Gov Docs Dept

Cambria County Library Sys
ATTN: Librn

Carleton College Library
ATTN: Librn

OTHER (Continued)

Carnegie Library of Pittsburgh
ATTN: Librn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Librn

Casper College
ATTN: Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Missouri State Univ
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN: Librn

Charleston County Library
ATTN: Librn

Charlotte & Mechlenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Librn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

Chicago University Library
ATTN: Dir of Libraries
ATTN: Docs Processing

Cincinnati University Library
ATTN: Librn

Claremont Colleges Libraries
ATTN: Doc Collection

Clemson University
ATTN: Dir of Libraries

OTHER (Continued)

Cleveland Public Library
ATTN: Docs Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: Docs Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: Docs Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

University of North Carolina at Asheville
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

OTHER (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College So Cpus
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: Docs Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN: Librn

Burlington Library
ATTN: Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: Docs Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN: Librn

East Islip Public Library
ATTN: Librn

OTHER (Continued)

East Orange Public Library
ATTN: U.S. Gov't Depository

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN: Librn

Eastern Kentucky University
ATTN: Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Docs Dept

Fond Du Lac Public Library
ATTN: Librn

Ft Hays State University
Ft Hays Kansas State College
ATTN: Librn

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Government Publications Library-M
ATTN: Director of Libraries (Reg)

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

University of Hawaii at Manoa
ATTN: Dir of Libraries (Reg)

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

University of Idaho
ATTN: Dir of Libraries (Reg)
ATTN: Docs Sec

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

Illinois University at Urbana-Champaign
ATTN: P. Watson Docs Lib

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

Jersey City State College
ATTN: F. A. Irwin Library Periodicals
Doc Sec

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

University of Texas
ATTN: Lyndon B. Johnson School of Public
Affairs Library

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

University of Kentucky
ATTN: Gov Pub Dept
ATTN: Dir of Lib (Reg)

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Lewis University Library
ATTN: Librn

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

Los Angeles Public Library
ATTN: Serials Div U.S. Docs

Louisiana State University
ATTN: Gov Doc Dept
ATTN: Dir of Libraries (Reg)

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Manchester City Library
ATTN: Librn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Kahului Library
ATTN: Librn

McNeese State University
ATTN: Librn

Memphis & Shelby County Public Library & Information Center
ATTN: Librn

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
ATTN: Librn

Murray State University Library
ATTN: Lib

OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN: Librn

Minneapolis Public Library
ATTN: Librn

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

University of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

University of New Mexico
ATTN: Dir of Libraries (Reg)

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Central Cultural Ed Ctr

State University of New York at Stony Brook
ATTN: Main Lib Docs Ser

State University of New York Col Memorial Lib
at Cortland
ATTN: Librn

State University of New York
ATTN: Lib Docs Ser

North Texas State University Library
ATTN: Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN: Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State
University
ATTN: Librn

University of North Carolina at Charlotte
ATTN: Atkins Lib Doc Dept

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
ATTN: Docs Librn

University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

OTHER (Continued)

Northeast Missouri State University
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
ATTN: Librn

Northwestern Michigan College
ATTN: Librn

Northwestern State University
ATTN: Librn

Northwestern State University Library
ATTN: Librn

Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN: Librn

Oakland Public Library
ATTN: Librn

Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN: Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librn

Oklahoma City University Library
ATTN: Librn

OTHER (Continued)

Oklahoma Department of Libraries
ATTN: U.S. Gov Docs

University of Oklahoma
ATTN: Docs Div

Old Dominion University
ATTN: Doc Dept Univ Lib

Olivet College Library
ATTN: Librn

Omaha Public Library Clark Branch
ATTN: Librn

Onondaga County Public Library
ATTN: Gov Docs Sec

Oregon State Library
ATTN: Librn

University of Oregon
ATTN: Docs Sec

Ouachita Baptist University
ATTN: Librn

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, GD

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Libm

Association of Portland Library
ATTN: Libm

Portland Public Library
ATTN: Libm

Portland State University Library
ATTN: Libm

Pratt Institute Library
ATTN: Libm

Louisiana Tech University
ATTN: Libm

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Libm

Providence Public Library
ATTN: Libm

Public Library Cincinnati & Hamilton County
ATTN: Libm

Public Library of Nashville and Davidson County
ATTN: Libm

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Libm

Quinebaug Valley Community College
ATTN: Libm

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Libm

Reading Public Library
ATTN: Libm

Reed College Library
ATTN: Libm

Augusta College
ATTN: Libm

University of Rhode Island Library
ATTN: Gov Pubs Off

University of Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
ATTN: Libm

OTHER (Continued)

Richland County Public Library
ATTN: Libm

Riverside Public Library
ATTN: Libm

University of Rochester Library
ATTN: Docs Sec

University of Rutgers Camden Library
ATTN: Libm

State University of Rutgers
ATTN: Libm

Rutgers University
ATTN: Dir of Libraries (Reg)

Rutgers University Law Library
ATTN: Fed Docs Dept

Salem College Library
ATTN: Libm

Samford University
ATTN: Libm

San Antonio Public Library
ATTN: Bus Science & Tech Dept

San Diego County Library
ATTN: C. Jones, Acquisitions

San Diego Public Library
ATTN: Libm

San Diego State University Library
ATTN: Gov Pubs Dept

San Francisco Public Library
ATTN: Gov Docs Dept

San Francisco State College
ATTN: Gov Pubs Coll

San Jose State College Library
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San Luis Obispo City-County Library
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Savannah Public & Effingham Liberty Regional Library
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Scottsbluff Public Library
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Scranton Public Library
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Seattle Public Library
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University of Richmond
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[illegible] Public Library
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[illegible] Library System
ATTN: Librn

[illegible] Memorial Library
ATTN: Librn

[illegible] Bronson Public Library
ATTN: Librn

[illegible] Public Library
ATTN: Librn

[illegible] College
ATTN: Librn

[illegible] State College Library
ATTN: Librn

[illegible] State Library
ATTN: Librn

[illegible] of South Carolina
ATTN: Librn

University of South Carolina
ATTN: Gov Docs

South Dakota School of Mines & Technical Library
ATTN: Librn

South Dakota State Library
ATTN: Fed Docs Dept

University of South Dakota
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South Florida University Library
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Southeast Missouri State University
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Southeastern Massachusetts University Library
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University of Southern Alabama
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Southern California University Library
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Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librn

Southern Illinois University
ATTN: Docs Ctr

Southern Methodist University
ATTN: Librn

University of Southern Mississippi
ATTN: Library

OTHER (Continued)

Southern Oregon College
ATTN: Library

Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
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Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN: Librn

St Louis Public Library
ATTN: Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN: Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
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State University of New York
ATTN: Librn

Stetson University
ATTN: Librn

University of Steubenville
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Stockton & San Joaquin Public Library
ATTN: Librn

Stockton State College Library
ATTN: Librn

OTHER (Continued)

Superior Public Library
ATTN: Librn

Swarthmore College Library
ATTN: Ref Dept

Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
ATTN: Librn

Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN: Librn

Tennessee Technological University
ATTN: Librn

University of Tennessee
ATTN: Dir of Libraries

College of Idaho
ATTN: Librn

Texas A & M University Library
ATTN: Librn

University of Texas at Arlington
ATTN: Library Docs

University of Texas at San Antonio
ATTN: Library

Texas Christian University
ATTN: Librn

Texas State Library
ATTN: U.S. Docs Sec

Texas Tech University Library
ATTN: Gov Docs Dept

Texas University at Austin
ATTN: Docs Coll

University of Toledo Library
ATTN: Librn

Toledo Public Library
ATTN: Social Science Dept

Torrance Civic Center Library
ATTN: Librn

Traverse City Public Library
ATTN: Librn

Trenton Free Public Library
ATTN: Librn

Trinity College Library
ATTN: Librn

Trinity University Library
ATTN: Docs Coll

OTHER (Continued)

Tufts University Library
ATTN: Docs Dept

University of Tulsa
ATTN: Librn

UCLA Research Library
ATTN: Pub Affairs Svc/U.S. Docs

Uniformed Services University of the Health Sciences
ATTN: LRC Library

Universities Libraries
ATTN: Dir of Lib

University of Maine at Oreno
ATTN: Librn

University of Northern Iowa
ATTN: Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN: Librn

University of Utah
ATTN: Special Collections

University of Utah
ATTN: Dir of Libraries
ATTN: Dept of Pharmacology

Valencia Library
ATTN: Librn

Vanderbilt University Library
ATTN: Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Librn

Virginia Military Institute
ATTN: Librn

Virginia Polytechnic Institute Library
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Sec

University of Virginia
ATTN: Pub Docs

Volusia County Public Library
ATTN: Librn

OTHER (continued)

Washington State Library
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Washington State University
ATTN: Lib Docs Sec

Washington University Libraries
ATTN: Dir of Lib

University of Washington
ATTN: Docs Div

Wayne State University Library
ATTN: Librn

Wayne State University Law Library
ATTN: Docs Dept

Weber State College Library
ATTN: Librn

Wellesley University
ATTN: Docs Librn

West Chester State College
ATTN: Docs Dept

West Georgia Library
ATTN: Librn

University of West Florida
ATTN: Librn

West Hills Community College
ATTN: Library

West Texas State University
ATTN: Library

West Virginia College of Grad Studies Library
ATTN: Librn

University of West Virginia
ATTN: Dir of Libraries (Reg)

Westerly Public Library
ATTN: Librn

Western Carolina University
ATTN: Librn

Western Illinois University Library
ATTN: Librn

Western Washington University
ATTN: Librn

Western Wyoming Community College Library
ATTN: Librn

Westmoreland City Community College
ATTN: Learning Resource Ctr

OTHER (continued)

Whitman College
ATTN: Librn

Wichita State University Library
ATTN: Librn

William & Mary College
ATTN: Docs Dept

Emporia Kansas State College
ATTN: Gov Docs Div

William College Library
ATTN: Librn

Willimantic Public Library
ATTN: Librn

Winthrop College
ATTN: Docs Dept

University of Wisconsin at Whitewater
ATTN: Gov Docs Lib

University of Wisconsin at Milwaukee
ATTN: Lib Docs

University of Wisconsin at Oshkosh
ATTN: Librn

University of Wisconsin at Platteville
ATTN: Doc Unit Lib

University of Wisconsin at Stevens Point
ATTN: Docs Sec

University of Wisconsin
ATTN: Gov Pubs Dept

University of Wisconsin
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librn

Wright State University Library
ATTN: Gov Docs Librn

Wyoming State Library
ATTN: Librn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Librn

Yuma City County Library
ATTN: Librn

Simon Schwob Mem Lib, Columbus Col
ATTN: Librn

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